Tropical Products Institute

Proceedings of the Conference on tropical and subtropical fruits

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Ministry of Overseas Development

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Introductory remarks

by the Chairman, Dr P. C. Spensley,
Director, Tropical Products Institute

Minister, Ladies and Gentlemen.

May I now start the proceedings of this 1969 Tropical Products Institute Conference by extending a very warm welcome to you all. My colleagues at TPI will also join with me in a further very special welcome to the delegates from overseas. It is indeed a very great pleasure to us all to have such a large number of specialists from abroad, representing, indeed, over 50 countries. This, more than any other single factor, will, I am sure, make for the success of this conference.

I would like also, if I may, to say at this point that we were very pleased to have the suggestion from the FAO that their conference on tropical fruit propagation should follow ours in this building and I would like to welcome those of the organizers and delegates who are with us already.

The name of the Tropical Products Institute is, of course, known to you all or you would not be here today; but you may not all know that we have been in existence and working on the problems of plant and animal products from the tropics for much longer than the 10 years, since we took our present name. In fact, our operations stem from the opening of a laboratory and the recruitment of two chemists in an establishment called the Imperial Institute; and that was way back in 1894. The stately Victorian building in South Kensington which used to house the Imperial Institute is, I regret to say, no longer in existence. However, the other main activity of that Institute, its educational and exhibition function, has been rehoused in a very fine building in Kensington which bears the name The Commonwealth Institute.

Now, I am going into this little bit of our history because it is to that sister Institute of ours that, with the kind permission of the Director, we are going tonight and we are holding the TPI reception at which my wife and I look forward to meeting you all. I would like to take this opportunity to say that if any overseas delegates have their wives, husbands or other relatives with them in London, they will be most welcome to bring them along with them this evening to this reception.

I should, perhaps, mention that we have not included any visit to TPI in the formal proceedings of the Conference as we are at present divided between two sites outside London and two buildings in London; one of which is at present undergoing extensive alteration. However, if any delegate would like to know a little more about the work of the Institute, I propose a very small gathering – and a very informal one – on Thursday evening about 6 o'clock in the Conference Room of one of our buildings, – which is about ten minutes walk from here. I shall be there to talk to people and we shall be able to see a 20 minute film about the Institute.

It is almost 5 years ago now since the Government of this country decided to create a new Ministry in order to bring under one administration all the various official aid activities for developing countries. This body was the Ministry of Overseas Development and soon after its creation the decision was taken that the Tropical Products Institute should become a part of it and, indeed, its largest scientific unit. It is therefore a special pleasure to have with us this morning Mr Reg Prentice, the Minister for Overseas Development. He has very kindly consented to open our Conference and without more ado I would like now to ask him to give us his opening address.

Opening address

by the Rt Hon. Reg Prentice, JP, MP,
Minister of Overseas Development

Mr Chairman, ladies and gentlemen, may I begin by welcoming everyone to this Conference, and particularly by welcoming all the delegates from overseas to Britain. This is in every sense a truly international gathering. I understand that there are fifty-two countries represented in this hall this morning, and countries clearly from all parts of the world and all stages of development. I also understand that you are in for a very busy time, in that you are going to listen to and discuss some forty-two papers by leading experts in various aspects of the subject matter of the Conference. That leads me to the conclusion that any opening address had better be reasonably brief, in order to enable you to get to the real business, and therefore, I want to detain you really only for a very few moments.

The first thing that I want to say is to congratulate, if I may, the Tropical Products Institute on its 75th birthday, and I am sure there are many people here in the gathering who would want to join me in that. As Dr Spensley has said it began in a small way in 1894 in the old Imperial Institute, and it has grown by many stages to the Tropical Products Institute as we know it today. In one sense, it has always been small, and it is still small; it is small in the number of people who are engaged in it. It is small in its cost to the British taxpayer, and its effectiveness despite its size has always been of a very high order indeed. It has played, and is playing now on the frontiers of development, a very distinguished part indeed, both in research and in applying the results of research in the field of tropical products. I feel I should quote here, with due humility as a politican, the words of the English writer, Jonathan Swift, over 200 years ago, when he said that "Whoever could make two ears of corn or two blades of grass grow upon a spot of ground where only one grew before would deserve better of mankind and do more essential service to his country than the whole race of politicians put together". Mr Chairman, the Tropical Products Institute of course goes a bit wider than blades of grass and ears of corn, but the spirit of those remarks, I think, is relevant to what you have achieved and what your colleagues are still achieving and will achieve in the years ahead in this vital field of activities. This conference is the third of a series. In 1965 the Tropical Products Institute sponsored a Conference on the oil palm; in 1967, a Conference on essential oil production. Both of those, I believe, produced results which have been of lasting benefit, in these particular fields of production, and this Conference, like those, brings together people from producing countries and people from consuming countries; in this case, in tropical and subtropical fruits I feel that in a sense I have an interest on both sides of this question, if there are two sides involved. Primarily, as Minister of Overseas Development, of course, I am concerned for the results this Conference might have for the producing countries and for the developing countries to whom the production of fruit is of such great importance.

I suppose it has become a cliché for opening speeches, after all opening speeches are allowed clichés, to say that one of the most important preoccupations of the developing world is to increase agricultural production in the widest sense and at the same time to diversify agricultural production. This of course means, among other things, increased production of fruit and the more efficient production of fruit as being a vital part in this process and a vital part, I think, for three main reasons.

The first reason being that the rate of production of fruit can make an important contribution to improving the diet of people in developing countries, providing the vitamins and the minerals that are so often lacking from the basic diet of people in poorer countries; secondly, that the production of fruit for export can play a growing part, and should play a growing part, in the economies of developing countries, earning the foreign exchange that they need, and therefore helping their development in a wider sense; and thirdly, that the growth of the production of fruit, particularly when it is associated with fruit processing industries can make a very important contribution to the production of fruit, particularly when it is associated with fruit processing industries can make a very important contribution to the employment difficulties of developing countries. This is something which we all need to pay a great deal of attention to.

One of the very sad facts about the 1960s is that while the basic goals of the United Nations Development decade are within sight, in the sense that an average 5% growth rate of the gross national product is being achieved by the developing world, another fact about the 1960s is

that in developing countries unemployment has been increasing. One of the things to which we need to pay particular attention in any consideration of development subjects, is how development can be particularly related to the employment situation. Here I think you have an aspect of the subject to which I hope you will be giving you attention during your discussions in the next few days. Mr Chairman, my other interest in your subject matter is, as a Minister of the British Government and a Member of the British House of Commons, our concern in Britain with topical and subtropical fruits as consumers and as importers. We have in Britain been importing tropical and subtropical fruits since the 17th century, and we now do so on a larger scale. Our total imports of fruits now amount to £120 million a year, about 2% of our total import bill. About two-thirds of this total are in the category of tropical and subtropical fruits, and therefore the British participants in this Conference and indeed the participants from many other countries will be looking at the problems as representatives of consumer countries. I have already said that this Conference will be bringing together producing and consuming interests. Also, as I understand from the gathering here, it will be bridging another gap; it will be bringing together, on the one hand, the technocrats, if I may use the word, the scientists and technologists who are involved in the technical problems of production, and, on the other hand, people with trade and commercial interests in this field. I suppose, if I may be guilty of yet another platitude, one of the great needs of our day in all industries and in all commerce is that those with the technical knowledge and those with the commercial skills should get together and be able to talk to each other's language, understand each others problems, perhaps to a greater extent that they often do in their day to day work. Again I think this Conference will make a practical contribution. I hope that you are going to have a good Conference, I hope that you will all in your various roles and from your various countries feel that you are gaining from this Conference something that will be of help to you in your practical work. Above all I hope that this Conference is going to make a practical contribution to the problems of the developing countries represented here, because I believe, and I hope everyone here believes, that the most important task facing us at the moment at this stage of the 20th century is that we should all of us in the developing countries and in the developed countries be working together to try and bridge the gaps between us; to try and raise the living standards of those who live in the poorer two-thirds of the world.

First Session

Monday 15th September
Morning

Chairman
Dr P. C. Spensley, Director
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Requirements for the establishment of a tropical fruit industry

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Summary

This review is concerned with the chain of operations from the time a crop is harvested until it reaches the consumer. Various food preservation and processing techniques can be used to control post-harvest enzymatic and other changes during storage and distribution or to give different types of products, e.g. canned, deep-frozen, dehydrated fruits or fruit juices.

In practice it is desirable to distinguish between:

(a) products for the home market; and

(b) products for export;

and to distinguish also between:

(c) large-scale processing corresponding to current practices in Northern Europe and elsewhere; and

(d) small-scale operations.

In this review special attention is given to:

(i) the technical requirements of new food industries making use of indigenous tropical or semi-tropical produce for local consumption;

(ii) the importance of close links between grower and processer in obtaining raw materials with characteristics suitable for the particular preservation or processing technique to be used;

(iii) the importance of quality appraisal at all stages.

Introduction

This Conference is concerned with diverse aspects of the production and utilization of tropical and subtropical fruits, both for use in the country of origin and for export elsewhere. In this introductory paper I propose to give a general survey and to focus attention on some of the barriers which must be surmounted if an agro-based industry—in particular a fruit industry—is to be successfully established.

This survey will be focussed on the so-called developing countries rather than on industrialized countries. Many developing countries are in tropical and semi-tropical regions; there are, however, many differences between groups of countries, for example between the older South or Central American republics, the countries of the Indian sub-continent and South East Asia, the newly independent African countries and the countries in the Middle East.

Pattern of Industry

From field to consumer

In Table 1, the word 'industry' is used to cover the whole chain of operations from production of fruit, through various stages of storage and transport, preservation and processing. In many cases the individuals or groups concerned with production may be quite distinct from those concerned with marketing and/or processing. Sometimes the processing or marketing agency has a direct financial interest in the growing of the crop; alternatively, the growers (as individuals, through syndicates or producer co-operatives) may be responsible for processing operations. In various countries there is (through state marketing boards or other bodies) some degree of state intervention, support or control.

In respect to fruit production, there are great variations in pattern, ranging from small-holdings to plantations. The pattern of production may be based on habit, or recent history and, in any one country, may vary from one type of produce to another.

Table 1

Pattern of Tropical and Subtropical Fruit Industries

A Production and Sale of Fruit	B Storage, Processing and Marketing
I Production	**I For Export**
1. Small holdings or	1. 'Fresh' fruit–without preliminary processing
2. Large-holdings or	2. Fruit with some preliminary preparation and processing for subsequent processing (e.g. canning) in importing country
3. Plantations	3. Fruit (or fruit products) processed (e.g. dried or canned or frozen) for sale in importing country
II Sale	**II For Local or 'Home' Use**
1. Through open market	1. Fresh fruit without preliminary processing
2. On contract basis	2. Fruit (or products such as juice) preserved for local sales:
3. Through producer co-operative	(a) Large scale production for national market
4. Through Marketing Boards or	(b) Small scale ('cottage industry') or medium scale for local or regional markets
5. Through transfer to marketing or processing section of firm owning the growing unit	

In considering storage, processing and marketing, we must distinguish between the older concepts of 'cash crops' for export and 'food crops' for home consumption. In the past, large proportions of 'fresh', semi-prepared or fully-processed tropical or sub-tropical fruits have passed through the marketing channels to supply the needs of industrialized countries of Europe and elsewhere. The present review is concerned with the establishment in developing countries of factories or processing units and with the relations between the local grower and the local processer.

Post-harvest Changes: Storage and Preservation

Fruits, like other products of agriculture, are biological systems and are subject to change in many different ways. Changes may be brought about by biological agents–by micro-organisms, insects or other pests–or through enzymatic and other biochemical reactions, in the harvested material. Such reactions can lead to changes in the chemical composition, cell structure, gross structure, form and in other characteristics.

Fruits are harvested at different stages of maturity; bananas, for example, are picked unripe so that ripening can take place during storage and transport by control of environmental conditions. For convenience the term 'preservation technique' may be used to cover this type of controlled storage as well as other methods of preservation and processing.

Some of these methods are listed in Table 2; two or more techniques are often used in conjunction with one

Table 2

General Techniques for storage and preservation*

A Controlled Environment	B Heat Treatment	C Dehydration and Related Methods	D Other Methods
1. Controlled atmosphere	1. Blanching	1. Sun drying	1. Sugar preservation
2. Reduced temperature – Chilling – Freezing – Newer cryogenic techniques	2. Pasteurisation	2. Dehydration by various methods including new techniques used as freeze drying	2. Salt
3. Packaging†	3. Bottling and glass packaging	3. Concentration	3. Chemical preservatives
	4. Canning		4. Fermentations
			5. Irradiation

* Two or more of these methods may be used in conjunction with one another.

† Effective packaging is essential in conjunction with many of the techniques.

another and to an increasing extent packaging, whether for bulk supplies or for smaller quantities, is becoming a key to a successful industry.

The basic principles behind many of the techniques go back to antiquity and are applied in various ways in different countries. Many of the techniques have now been changed under the influence of science and technology to give the foundations of the modern large-scale food industries. (Aylward 1970 e). Parallel to such modern techniques (e.g. in respect to freezing or dehydration), traditional methods (e.g. sun-drying and wine-making) still occupy a very important place in the economies of different countries.

Details of the various techniques are given in monographs dealing with specific processes and also in standard general texts such as Blakebrough (1961/68), Borgstrom (1968), Clarke (1957), Hawthorne and Leitch (1960), Jacobs (1951), Leitch and Rhodes (1963).

Types of Products

In Table 3 are listed some of the main types of fruit products beginning with 'fresh' fruit which retains its original form, although it may have been subjected to controlled environmental storage for short or long periods, and may be protected by flexible packaging material.

The table also notes some of the by-products of fruit processing involving extracts of seeds, skins and other processing residues. Cruess (1958) gives details of the many diverse types of by-products from different fruit processing operations; these by-products may be important commercially and also in relation to the problem of disposal of factory wastes.

Tables 2 and 3 are in no way complete but they illustrate the many different facets of the fruit industries with the wide range of fruits available, the extensive list of preservation and processing methods and the great variety of final products and by-products.

Table 3

Fruits, Fruit Products and By-products

Products	Methods and Notes
I Fruits–'Fresh'	Short term preservation by controlled environment
II Fruits–'Processed'	Short term or long term preservation by (combination of) methods of Table 2
1. Canned	
2. Frozen	
3. Dehydrated	
4. Other methods	
III Unfermented Fruit Juices and Comminuted Pulps	Preservation by methods of Table 2
1. Juices	
2. Nectars	
3. Concentrates	
4. Pastes	
IV Fermented Products	Often by traditional methods
1. Wines	
2. Other fermented products	
3. Products of distillation	
V Some other products	
1. Jams and marmalades	
2. Other sugar products	Such as crystallised fruits or candied peel
3. Pectins	
4. Dietetic products	Including infants' foods containing fruit
VI Some By-products from Fruits or from Processing Residues	
1. Glyceride (fatty) oils 2. Essential oils	From seeds, skins and other materials
3. Components for animal food 4. Components for fertilisers	From different types of residues.

Traditionally there are two main sectors of the fruit industry; the first covering fresh fruits, the second, fruits preserved or processed. In practice, the distinction is breaking down in that fruit often has to be subjected to some controlled environmental treatment for storage or transport. Moreover, the movement towards pre-packing, as shown in the supermarkets of industrialized countries, may involve the use of protective coatings on the fruit itself or in the packaging material.

The Establishment of Processing Units:

Table 4 summarises the main technical factors that have to be taken into account in the planning of a processing centre. There is comparatively little technical literature on this subject in relation to developing countries although much useful information can be obtained from some of the standard text-books on fruits and fruit products, e.g. Duckworth (1966), Cruess (1958), Morris (1951), Rauch (1965), Tressler and Joslyn (1961), or in general texts on food preservation Jacobs (1951), Desrosier (1963), Joslyn and Heid (1963), Peterson and Tressler (1963 and 1965), or in texts on specific processes already noted. Recent reviews on the position in developing countries are provided in the FAO Report, Anon (1967a) and other papers, Aylward (1969 a, b, 1970 a).

Raw Materials and Supplies

In Table 4, raw materials and supplies have been divided into four main headings. In the first place, we have the agricultural raw materials to be processed. The food processing industries, as they have grown in Europe and elsewhere, emphasise the importance of the chain of linked operations extending from the farmer or grower (the primary producer) to the consumers. In planning a factory, it is essential that arrangements can be made to secure raw materials of the right quality, in the right quantities and at the right time. This question of *quality* will be discussed later but at this stage we should note the importance of close working arrangements, financial and technical, between grower and processer.

A second raw material, frequently ignored in planning, is water. Fruit processing operations may use considerable amounts of water for a variety of operations (steam raising, cooling and cleaning, and for syrups or other liquids to be used in the processing). In many industrialized countries water supplies have become limiting factors in food operations; in developing countries the water supply may be of special relevance, either because of arid conditions or because of great seasonal variations. Apart from *quantity*, the *quality* of water is of importance in many operations. Precautions must be taken to carry out regular chemical and microbiological examinations and to ensure hygienic standards.

Table 4

Fruit Processing

Technical Requirements

1. **Raw Materials and Supplies**
   - (a) Agricultural materials
   - (b) Water
   - (c) Auxiliary chemicals
   - (d) Packaging materials

2. **Design and Equipment of Factory**
   - (a) Buildings
   - (b) Major equipment
   - (c) Auxiliary equipment
   - (d) Storage facilities for raw materials and final products

3. **Services and Supplies**
   - (a) Power
   - (b) Water
   - (c) Transport facilities for raw materials and final products
   - (d) Means of effluent disposal
   - (e) Repair and maintenance facilities

4. **Labour, Technical Control and Management**
   - (a) Skilled and unskilled labour
   - (b) Scientific, technical, quality control and management personnel
   - (c) Access to consultants or consultancy services and laboratories

5. **Availability of Markets**
   For local or internal trade and/or exports

6. **Location of Factory**
   In terms of (1) to (5) and other considerations

Depending on the processing method to be used, a range of auxiliary materials (e.g. sugar, syrups, flavours) will be required, and for most processes, suitable packaging materials. The auxiliary and packaging materials are often not available in a developing country and their import may be difficult because of currency restrictions. In some developing countries can-making plants have been established, but such plants often require the import of tin-plate and a variety of other supplementary materials, (e.g. lacquers).

Thus, in planning an enterprise, it is essential to conduct a technical-cum-economic appraisal of the cost of such materials and of their addition to the cost of the final products. An analysis from a distance may be incorrect; thus in the United Kingdom glass-packing is usually more expensive than canning; the reverse may be true in another country where bottles can be made locally from indigenous materials and where the re-use of bottles (as in the milk industry) may be economically satisfactory. Newer heat-treatment techniques involving the use of synthetic packaging materials may become of special importance in developing countries.

Design and Equipment of Factory

Food processing factories in Europe and elsewhere are normally designed by individuals or groups with long experience in similar enterprises and in the use of equipment. In many developing countries, no such people are available and it is not always appreciated that in the design of a factory, or in the purchase of equipment no amount of theoretical scientific knowledge can be a substitute for practical industrial experience.

The problem is, of course, reduced when a new processing enterprise is affiliated to, or in partnership with, some expatriate firm, but this is not always possible—especially for small or medium-sized indigenous enterprises—and other methods have to be adopted.

Various consulting groups now operate in the international field, and some equipment firms or development consortia have advisory services and are ready to consider the supply of complete factories. This avoids one major difficulty—that in industrialised countries, major and minor items of equipment (for example, for a canning factory) may have to be purchased from twenty or more firms.

Plans for tropical and subtropical countries must include a survey of (a) the types of operations, (b) the special problems of equipment under tropical conditions, as well as the question of size and scale.

A large factory in Europe may confine its operations to one method of preservation, (e.g. canning or dehydration), or to a very limited range of products. In a developing country, a factory for export may operate on more or less the same lines as in Europe but for the internal market it may be desirable to envisage, in the preliminary stages at least, flexibility in operations, and to take this into account in the design and layout of the factory and the choice of equipment.

In selecting equipment, special consideration should be given to the possible effects of tropical environmental and working conditions. Thus equipment should be designed to stand up to tropical heat; surface coatings should be chosen to withstand heat and humidity. Tropical conditions favour the growth and activity of micro-organisms, insects and other pests, so that it is important to have equipment that can readily be dismantled for inspection and cleaning. Because of difficulties of maintenance and of replacement of items which need to be imported, many advisers favour less complicated equipment than is now fashionable in Europe; current trends in automation do not necessarily produce better products; they are justified largely in terms of the very high labour costs.

In the overall design of a factory, there is much to be said for the one-storey, simple type of construction; a point sometimes ignored is the necessity of provision of adequate storage buildings for initial raw materials, auxiliary materials, and final products.

Services

The question of water supplies has already been mentioned; adequate power supplies for steam raising and other purposes are clearly a necessity. A major problem of factories in industrialized countries (and especially those in urban areas) is that of the disposal of waste materials and effluents; the cost of disposal becomes, in many cases, an appreciable percentage of the operating costs of a factory. This matter cannot be ignored in a developing country; there is much to be said for the examination of the possibilities of making the fullest use of factory by-products and for a survey of composting and other modern effluent treatment systems.

Transport facilities are especially important in developing countries where the main road and railway system may be inadequate and minor roads in rural areas deficient.

Labour, Technical Control and Management

In developing countries, unskilled labour may be readily available, but scientific, technical and management personnel in short supply. Technical training facilities at all levels are an essential, but often neglected, component of plans for industrialization. In many countries in Africa, the Middle East and elsewhere, a major difficulty is the absence of facilities for food science work at the University level and of technicians' courses in food processing at sub-university level. Countries that wish to initiate or expand their fruit processing industries (or the food industries in general) should make every effort to send key personnel abroad for a year's practical experience in a factory.

In the absence of experienced technologists, access to consulting groups or laboratories is essential; even in the United Kingdom, with all the changes in recent years, industrial research associations, such as the Fruit and Vegetable Preservation Research Association at Chipping Campden, still play an important consultancy and 'trouble-shooting' rôle in addition to their research programmes, Anon (1969 a). The Food Research and Development Centres established in countries such as Ghana and

the Sudan with the support of the Food and Agriculture Organization and the United Nations' Development Fund have potentially very important consultancy rôles in respect to fruit processing, as well as in relation to other food products.

Markets

The question of marketing of products cannot be discussed in detail here, but it is important to note that technical as well as economic and other factors must be considered. For internal trade, local traditions, recent changes and the extent of imports can be used as a rough guide; for external trade much wider surveys are necessary. The type, quality and standards of products to be made will depend on the nature and situation of markets.

Location of Factory

Decision on the location of a factory should be settled in terms of the earlier points discussed. Social and political factors often play a determining and sometimes an unfortunate role. For many types of fruits, the preliminary prepâration and preservation operations must be carried out as near as possible to the growing areas if quality is to be maintained.

Grower/processer Relationships: Scale of operations

The Grower-Processer relationship

The processing enterprise must take into account the available, or potentially available, supplies of raw materials; conversely, the primary producer can plan realistically only in terms of available—or potentially available—markets. In the United Kingdom canning, freezing and other food processers are more and more concerned with contractual relationships with the individual grower, or with syndicates or co-operatives. The same pattern is emerging in other industrialized countries. (Aylward 1970 a, b). These relationships go far beyond financial transactions; they involve a two-way traffic of ideas between grower and processer. Many food firms employ large numbers of agricultural liaison officers whose task is to work with the grower and to provide advice on matters related to the quality of the desired raw materials. (Aylward 1970 b).

The question of *quality* of raw materials coming to the processing centre is all important. In traditional horticulture, fruits and vegetables have been grown primarily for immediate use for local markets. It is not always appreciated that the characteristics required in fruits for processing may be different from those required for the fresh market. Moreover, the different types of processing techniques (e.g. canning, juice extraction, jam making) may require different characteristics in the raw materials.

Thus a fruit-processing development programme often involves the introduction of new cultivars and the elimination of cultivars which are unsuitable for processing. New cultivars must, of course, fulfil ordinary horticultural requirements but the net result is a reduction in the number of cultivars in a given region, with a concentration on those of special value.

Major food enterprises in the United Kingdom and other importing countries, have initiated similar programmes in several tropical and subtropical areas as the basis for plantation production or in co-operation with local small-holders. This activity is of special value because, in the past, Agricultural Advisory or Extension Services have often been concerned primarily with production for the fresh market.

Schedule of Operations

There is one special feature of processing operations that must be mentioned, namely the importance of arranging schedules so as to ensure as far as possible, (i) that the processing plant is working to full capacity at any one time; and (ii) that operations can be carried out continuously throughout the year.

In practice, this ideal may be difficult to attain; some factories have to work on a seasonal basis with all the consequent difficulties of unemployment out of season, as well as economic wastage of capital invested in installations. It is for this reason that pre-investment surveys must consider a week-to-week programme in terms of fruit likely to be available, storage facilities for surpluses and diversity in operations. In the United Kingdom, the canned processed pea was introduced in part to make use of the vegetable canning factory outside the relatively short garden pea season. Many factories base their annual schedules on both fruit and vegetables and a similar policy may be required in tropical and subtropical areas.

Scale of Operations: The Concept of Intermediate Technology

In industrialized countries, there has been a tendency—accentuated in recent years—to build large canning or other processing factories with large-scale plant and equipment and the maximum degree of automatic control. There are many reasons for this, in particular, the rising costs and scarcity of labour, and the desire to maintain rigid control over processing conditions. In tropical countries there are examples of large factories which are being run successfully, but there are, unfortunately, examples which are far from successful—in part, because of their excessive size. Aylward (1961 a, b, 1963) has pointed out the potential advantages of small-scale enterprises, but some consultants, up to comparatively recently, have been only too ready to recommend a complete duplication of Northern European or North American techniques. Fortunately, there has become available over the past few years a body of literature concerned with 'Intermediate' (or 'Appropriate') Technology. (Anon, 1970b).

Various publications by Schumacher and others, Anon, (1969 b) have discussed in social, economic and technical terms the relative advantages of small-scale and large-scale enterprises.

From such analyses three points emerge:– (i) that there is no room for dogmatism; there is a place for large-scale processing units especially in areas processing major crops for export but that there is scope also for small-scale industries of varying sizes especially in relation to 'home' consumption; (ii) that decisions should be based on a full knowledge of local conditions and possibilities; and (iii) that the case for labour-intensive (as distinct from capital-intensive) industries may be very strong in tropical and subtropical countries in relation to food processing–including the processing of fruits and fruit products–for home consumption. The arguments in favour of (iii) include the desirability of providing employment in rural areas and of encouraging the technical and business potentialities of local people. On this basis it can be argued that development plans in respect to fruit processing should encourage different and diverse types of enterprise from village bottling activities to medium and large-scale factories.

Quality Standards and Nutrition

Quality Standards

The quality of final products depends on the initial quality of raw materials, good conditions of harvesting and transport from field to factory, and the efficiency of processing operations and storage of final products. Advice to member firms on quality standards is an important aspect of the work of co-operative research associations in different countries; methods of appraisal are reviewed in various monographs, Anon. (1960), Kramer and Twigg (1962), Herschdoerfer (1967/8).

It is a fundamental principle of quality appraisal in a factory that responsibility should be divorced from production management; in a small factory some means should be found whereby 'outside' individuals or panels can give objective criticisms, comments and advice.

Food Hygiene and Toxicology

Microbiological and other biological appraisals (e.g. for the presence of insects or their residues) are an essential part of any quality control operation. Hygiene deserves a special mention because of its importance to human health and because few things can destroy the reputation of an enterprise more quickly than outbreaks of food poisoning.

Linked with hygiene is the question of toxic effects of accidental and intentional chemical additives, arising from crop protection chemicals, processing aids or other sources. More and more countries are imposing rigid limits for such residues and a knowledge of current trends is important both in regard to the health of local communities and to the import restrictions of European and other countries. Various reports on food standards, additives and contaminants from the UK Ministry of Agriculture, Fisheries and Food, Anon. (1969 c) may be useful for reference together with reports on the progress of the Codex Alimentarius.

Nutrition

It is well recognised that fruits, fruit juices and other products are important items in the diet and may provide not only vitamin C and other essential factors, but may make also a more general contribution, Tressler and Joslyn (1961); Cruess (1958); Anon. (1968); Davidson and Passmore (1969). Although in current nutritional surveys of developing countries attention is often focussed on the protein problem, the role of vitamins in a balanced diet cannot be ignored. If fruit juices or other products are to be used in hospitals or elsewhere as a source of vitamin C (ascorbic acid) then routine checks on initial and stored products must be carried out as part of quality control.

Conclusions

This paper has covered a wide range of topics and inevitably contains generalizations which do not apply to all fruits, or to all products or to all regions. Some of the points mentioned–for example, in relation to grower-processer relationships or to the technical planning of a factory–will be obvious to those who themselves are concerned with large and successful enterprises. On the other hand, most food industry consultants in Africa and elsewhere will agree that there is indeed a gap between food processing and agriculture in many areas and that there are many examples of errors, resulting in heavy financial losses to governments or individuals, in the planning of enterprises in relation to location, size, equipment and supplies of raw materials.

The technical topics considered in this review have been concerned primarily with the *establishment* of food enterprises, but many of the topics are equally relevant to to the successful *functioning* of the enterprise. Success will depend on an integrated approach taking fully into account technical matters and economic, financial and managerial considerations.

This review can perhaps be summarised in terms of three points. Firstly it is essential that those concerned with new fruit enterprises in developing countries should obtain sound objective advice and ensure that those who are to be in charge of operations have, or receive, practical experience in similar operations. Next, it is essential that a country that intends to build up fruit and other food enterprises should build up adequate educational and training schemes. Thirdly, it is essential that a two-way traffic of ideas be encouraged between those concerned with agricultural or horticultural production and those concerned with the planning and functioning of new food preservation and processing enterprises

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The marketing of tropical and subtropical fruits in Britain

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Summary

The marketing trends in the United Kingdom of the principal types of tropical and subtropical fruits are described. Reference is made to production, at international level, which is relevant to United Kingdom marketing in view of the unrestricted entry into the United Kingdom of both fresh and processed fruits, other than apples and pears.

Reference is also made to the different systems of marketing and distribution where marketing boards are operative, as distinct from the free interplay of private enterprise. In the latter case various methods of financing and risk bearing are specified.

Modern trends in transport and packaging as being relevant to both the efficiency and the costs of marketing are also discussed.

The fruits covered in the paper are citrus, pineapples, avocados, bananas and dates.

Among the most important of the subtropical fruits is the citrus group, spread broadly over oranges, grapefruit, lemons and mandarins, with the seedless varieties of clementines and satsumas.

Citrus fruits, with the exception of clementines and satsumas, are produced in quantity in both the East and West, while the production of clementines and satsumas is more specialized and, in the West, confined largely to Spain and North Africa, and in the East to India, China and Japan. In Japan the production of satsumas has given rise to a very important processing industry, where the production of 'mandarin segments' has become a first class quality article marketed in many parts of the world.

In the course of international research it has been established that there is a general over-production of citrus which could produce acute marketing problems should all producing areas achieve normal production during the same season. Producing countries, where possible, have reacted to the threat of over-production by the gradual elimination of poor quality and undesirable varieties, but while these activities are very praiseworthy, there has also been a tendency to introduce other varieties with a view to a prolongation of the season of production and, therefore, of marketing which, together with constantly improving storage techniques, can again lead to the marketing of excessive quantities from various sources in the same zone of production.

There is a constantly changing pattern in the overall marketing of citrus fruits, as shown by the impact in comparatively recent times of deep frozen, concentrated pure orange juice, whether in consumer packs or larger manufacturing containers, such as the A 10 can. Leaders in this field of processing are the United States, where a very large proportion of the Florida citrus crop is now processed and marketed in this form, and South Africa, where there is rapidly increasing development on similar lines. In certain countries where pure juice with the typical fruit flavour coupled with the full nutritional value and packed without preservative is appreciated, this product has been a strong competitor to the traditional single-strength citrus juices, whether packed in consumer containers or catering packs.

Both forms of processing have been of great value to the producer in that a large tonnage of varieties of citrus with the necessary juice weight ratio and sugar acid ratio can be absorbed. These in their fresh state, owing to the structure of the fruit, are not always a desirable product for the consuming public due, for example, to difficulty in peeling and excessive 'rag' content in the fruit itself.

The marketing of these processed lines is generally concentrated in the hands of exclusive specialist distributors in the various consuming markets, but there are a variety of patterns of marketing and distribution in regard to fresh fruit. There is no doubt that due to increasing competition, rising costs of packaging, transport and marketing, the tendency has been and is, to establish marketing boards handling the fresh exports of many producing countries. Specific examples which can be quoted are the Citrus Marketing Board of Israel, the Official Marketing Board of Morocco, the South African Citrus Board and co-operative marketing through sole agents of citrus from parts of the West Indies.

A major producer where as yet no marketing board has been established and where various exporters conclude arrangements with their overseas marketing salesmen, is Spain, but in that country also there is a tendency for the establishment of larger but still independent organizations co-ordinate the activities of the multiplicity of smaller exporters. This has been accelerated by the new methods of packing and the need for mechanization and the provision of adequate tonnage for transport, which in many cases would be uneconomic to the smaller shippers.

In the case of Brazil, where this industry has emerged from the tragedy of almost complete elimination from the disease *Tristeza* to a major producer, while no marketing board exists, there has been a noticeable move towards the formation of large and co-operative organizations jointly with the emergence of a major processing industry.

As yet there has been no concrete form of international marketing of citrus, although it is significant with the formation of the Comité Permanent de Liaison de l'Agrumiculture Méditerraniénne (CLAM) that the eventual possibility of such activities is envisaged. This is a consultative body formed to discuss the problems of marketing, transport and varieties, but it is not unreasonable to assume that it could evolve into a much more concrete form of international marketing. It is also possible that eventually, apart from the individual advertising campaigns of the various producing countries, there could be a unified effort for background advertising in citrus fruit from whatever sources of production. An interesting, recent development is an agreement by citrus producers in the Murray River district of Australia to market their fruit in the United Kingdom through an established British apple packing co-operative organisation who would provide on the spot packing of the fruit from bulk containers, together with marketing know-how which has been evolved through their disposal of large quantities of home grown deciduous fruit.

In the case of those countries operating through marketing boards or similar organizations, the pattern is generally to effect distribution through a restricted number of selling organizations in the importing countries with adequate sales capacity at strategically placed premises.

The fruit, in most cases, is sold on behalf of the marketing board by members of the 'panel' on a commission basis at a rate agreed between the panel salesmen and the marketing board. Adequate guarantees of financial responsibility are provided and both sales and stocks are assessed efficiently on a day to day basis.

In the case of those countries where no marketing board exists, the same system operates to a considerable extent in that the individual exporter will deal with a number of importing firms on a commission basis. Here there are variations such as joint account ventures where both exporter and importer share profit and loss, or shipments to be sold on commission but based on a guaranteed minimum figure paid in advance by the importing firm. These provisions apply broadly to all types of citrus fruit. It is, however, important to note that the elasticity of demand is far greater for grapefruit and lemons than for oranges, and that in many countries the demand for mandarins, satsumas and clementines is on a seasonal basis. In the United Kingdom for example, the outlet is concentrated on the months of November and December with special reference to the Christmas market.

It is also essential to note in the modern context that where citrus is processed, the valuable by-product of essential oils is extracted for the manufacture of perfumes and other products. Further recent development ensures the utilization at factory level of the whole of the product by the dehydration and milling of the residue after extraction of juice and oil, which is then compressed into powder or cake form for use as a cattle food ingredient.

Pineapples

In the case of pineapples the production of the fruit, other than in certain isolated instances such as the Azores, is based primarily on the processed article. The heavy production of canned pineapples in the USA Hawaii, Mexico, southern Africa, Malaysia and Taiwan, to cite a number of concrete examples, is based on the production of varieties which provide the maximum flesh content when processed by modern machinery.

The marketing of the canned product is operated on a similar basis to that of citrus fruit, in that there are certain established marketing organizations specializing in this product which effect distribution in the various consuming countries. With the perfection of canning machinery the fruit is sold in a number of forms, all of which have a ready outlet through the different tastes of the consuming public, such as rings, chunks and pieces, and are marketed in consumer packs varying from the small 8-oz to the large A 2½ can, while there is still a considerable production in the large A 10 cans for catering and processing purposes, including the so-called by-products of juice and crush.

Again the peel residue of the pineapple, while not containing an oil content of value, is in many cases processed in the form of dehydrated powdered cattle food which is blended with other products to provide winter feed.

Avocados

The development of the production and marketing over long distances of tropical fruits has evolved very considerably over recent years, and a concrete example is that of the avocado. As a result of research in depth at production level, and well organized promotion, consumption has increased very rapidly. It can be considered that this fruit is an outstanding example of enterprise and co-operation, and although such other tropical fruits as mangoes, guavas, persimmons and papayas are also increasing their marketing radius, the progress has been very slow in comparison with the overall position of the avocado.

To cite specific countries, Israel and South Africa have made vast progress in both the production, packaging and marketing of this fruit and in their promotion schemes which bring to the notice of the consumer in clear and simple language the various means of preparation.

Bananas

It is difficult to enlarge on the production and marketing of bananas without the appearance of glimpses of the obvious. This is, however, a major industry in many countries and certainly so far as consumption in the United Kingdom is concerned, is one of the leading tropical fruits.

Owing to the necessity for high levels of expertise in production, transport and marketing, the tendency has been for the handling of bananas to be concentrated into the hands of a very limited number of large organizations able to provide technical supervision, research into varieties, transport and internal marketing, where very large financial resources are involved.

The recent development where the hands of bananas are cut from the stem at source of production and graded then packed into cartons, as against the previous system of the shipment on the stem in green condition to be ripened and cut in the consuming country, is a most interesting technical achievement.

Dates

Dates are imported into the United Kingdom from a number of Mediterranean and Middle Eastern countries. The best known pack, having in mind its wide retail distribution, is the traditional so-called glove box containing 8½-ozs net of selected and graded dates, the traditional line for the Christmas trade.

These dates are grown in Tunisia and in Algeria and considerable quantities are shipped to Marseilles in bulk, where traditional packers grade and pack this product.

There has been, however, a considerable development in dates of a different variety from Iraq, Iran and Egypt, where the fruit is pressed and packed in cellophane, in individual packages of four to eight ounces. A limited quantity is also shipped in pressed large blocks for weighing at retail point of sale. This type of presentation is gradually disappearing from the United Kingdom markets with the rise in living standards.

The dates are processed and sterilized to ensure that there will be no insect contamination, and recently the Tunisian authorities have intalled extensive packing equipment with a view to carrying out the whole operation direct from Tunisia to the overseas markets. A further recent development has been the export from Israel of fresh, as distinct from processed, dates which are now being introduced to the overseas markets.

Transport and packaging

The development of new methods of transport and preservation in recent years are applicable to all types of fresh tropical and subtropical products. The development of the smaller container which enables ease of handling at retail point of sale is indicated by the speed with which the standard Florida pack with a content of 66 lb net of citrus fruit and heavy returnable 28 lb banana boxes are rapidly disappearing. The substitution of the 14 lb and 21 lb banana carton and the 33 lb carton and bruce box for citrus fruits have not only immensely facilitated handling at the retail point of sale, but have also promoted research into the use of pallets where, due to the dimensions of these containers, maximum utilization can be ensured, for example, on the expendable or even the returnable pallet with the dimensions of 40 ins × 48 ins.

Cargoes, where palletized or shipped in containers, require a standardized pack and in the case of the products mentioned, the dimensions of the containers which have been evolved are ideally suitable to palletization.

It can be expected that in due course cargoes shipped in the ten and twenty ton containers of international standards dimensions will also be palletized, thus ensuring a minimum of handling with consequently reduced damage both to the individual container and the fruit therein.

Apart from the use of traditional cool air refrigeration and the further development of controlled atmosphere, the research which is now being carried out into the incorporation of a percentage of inert nitrogen whether for purposes of transport or for long-term storage, will certainly have far reaching results.

It is true to say that in the case of handling at whatever level, the constantly increasing costs of handling and transport provide an overwhelming incentive to devise every possible means to avoid wastage, damage and delay, as also the elimination of inferior quality produce. In fact, the selective approach of the consumer fostered by generally increasing standards of living, together with the competition of convenience foods and the impact not only of rising labour costs but costs of demurrage on specially equipped means of transport, provide a vital and exciting field for scientific research in the marketing of fresh produce.

United Kingdom Imports

Oranges

Oranges *Sweet*	*1966*	*1967*	*1968*
		tons	
Australia	711	-	1,789
Cyprus	12,971	18,523	14,928
Swaziland	1,076	701	1,106
Other Commonwealth	5	53	18
Argentine	-	102	144
Brazil	15,178	19,824	14,233
France	768	345	461
Greece	835	814	1,648
Irish Republic	752	594	282
Israel	117,034	131,717	155,824
Morocco	19,488	21,229	24,306
Mozambique	746	1,305	3,017
Netherlands	1,320	1,083	452
South Africa	92,063	98,479	97,440
Spain	106,298	66,678	53,700
United States	2,391	6,779	124
Other foreign	1,602	816	328
Total	373,238	369,042	369,800
Bitter			
Cyprus	91	159	170
Irish Republic	68	62	72
Italy	1,792	2,822	1,999
Spain	16,033	13,241	12,166
Other countries	40	5	285
Total	18,024	16,289	14,692
Mandarins, etc.			
Cyprus	368	367	362
Jamaica	497	617	760
Israel	103	-	118
Italy	64	53	27
Morocco	3,787	5,932	6,802
Spain	17,038	13,402	15,059
Other countries	709	238	216
Total	22,566	20,609	23,344

United Kingdom Imports

Grapefruit

Grapefruit	*1966*	*1967*	*1968*
		tons	
Cyprus	11,377	14,562	16,905
Jamaica	1,096	1,724	1,152
Nigeria	87	207	183
Swaziland	4,234	5,724	5,082
Trinidad	4,226	2,035	1,424
Windward Islands	1,380	1,877	1,821
Other Commonwealth	11	283	1
Argentina	80	43	31
Brazil	130	118	682
Israel	29,465	27,591	41,142
Morocco	923	1,055	454
Netherlands	19	557	16
Mozambique	2,192	3,895	1,857
South Africa	17,027	17,394	18,761
Spain	1,102	802	1,061
United States	533	1,446	156
Other foreign	1,500	488	685
Total	75,382	79,801	91,413

United Kingdom Imports

Lemons and other Citrus

Lemons and other citrus	*1966*	*1967*	*1968*
		tons	
Cyprus	3,642	4,236	5,262
Jamaica	598	558	479
Swaziland	11	82	18
Other Commonwealth	26	31	21
Belgium	266	55	80
Greece	312	104	18
Israel	2,134	2,124	2,527
Italy	19,298	18,402	20,166
Netherlands	151	213	537
South Africa	3,678	3,393	2,357
Spain	493	875	362
Turkey	-	61	26
United States	1,972	2,828	1,674
Other foreign	360	403	360
Total	32,941	33,365	33,887

United Kingdom Imports

Bananas and Plantains

Bananas and Plaintains	*1966*	*1967*	*1968*
		tons	
Ghana	660	557	936
Nigeria	424	496	246
Jamaica	188,870	178,705	150,081
Windward Islands	161,625	159,123	178,817
Canary Islands	4,849	3,443	2,774
Cameroon (West Cameroon)	5,677	2	-
Colombia	-	400	1,501
Ecuador	-	7	2,682
French West India Islands	131	2,367	1,127
Irish Republic	1,093	1,154	2,310
Panama	-	-	628
Other countries	53	1,449	119
Total	363,382	347,703	341,221

United Kingdom Imports

Dates

Dates (stoned)	*1966*	*1967*	*1968*
		tons	
Iran	1,723	3,876	3,479
Iraq	5,989	5,483	2,476
Netherlands	286	27	5
United States	82	10	6
Other countries	77	5	34
Total	8,157	9,401	6,000

Reference:

Fruit Intelligence Feb 1969, XIX, 2, 78-130

tons

Dates (Other)	*1966*	*1967*	*1968*
Algeria	87	222	28
Belgium	61	17	24
France	4,638	3,228	2,900
Iraq	70	432	169
Israel	2	8	82
Spain	6	3	26
Tunisia	450	208	219
United States	280	171	40
Other foreign	49	54	24
Total	5,643	4,343	3,512

United Kingdom Imports

Avocado Pears

cwts

Avocado Pears	*1968*
Kenya	1,742
Uganda	12
Barbados	10
Jamaica	772
Portuguese East Africa	120
United Arab Republic (Egypt)	105
Ivory Coast	67
South Africa	23,973
Lebanon	7
Israel	18,068
USA	77
Brazil	99
Total	50,640

The trade in tropical preserved fruit

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Summary

The range of items and origins of tropical food products at present selling on the market is considered, along with the methods of marketing in the UK. There are items which might be sold on this market if packed in accordance with specified labelling, packing and means of transportation.

Technical aspects including common faults in production, preservation methods and the importance of high quality production in the development of sales are subjects to be covered, particularly in connection with the preserved fruit industry of today.

Aspects of the development of a new business must be carefully considered. Basically these involve plant and machinery, long term credit, counter purchase, product research and development with quality specification of the market concerned. Publicity of these preserved tropical fruit is of major importance to aid expansion in the UK market.

In recent years there have been many changes in the distribution pattern of imported retail packs of foodstuffs in the UK. This has been due largely to the fast development of the multiple chain store or supermarket whose buyers purchase directly from UK manufacturers and importers; also to the development of the wholesale associations such as Spar, Vivo, etc., who buy certain items centrally in the name of their wholesale members. In the multiple trade the tendency in recent years has been for the companies to buy for sale under their own brands rather than the brands of the packer or the importer–approximately 65% of all sales in multiple stores today are in the brand names of the multiple groups.

The sale of tropical fruits in cans has been in the past a business in which the leading multiples and wholesalers were uninterested owing to the relatively low volume of sales, also the scarcity and increasing cost of display space in wholesalers' warehouses, cash and carries, retail shops and supermarkets. The tendency was, therefore, to organize such distribution in shops carrying a wide range of delicatessen lines and in various health food shops. Today, however, we find that some of the bigger buyers are interested in tropical fruits, particularly if these fruits are packed in small sizes with a corresponding lower unit price. To take an example, the sale of lychees in an A2 can (20 oz.) was almost entirely restricted to the catering trade for distribution to restaurants selling Chinese type foodstuffs–however, since we packed these lychees in an 11 oz. pack (similar to the size in which one normally buys Japanese mandarin oranges) there has been a very substantial demand by the public and multiple buyers such as Sainsbury have built up an important trade selling under their own labels in this size. I believe that this principle can also be applied with advantage to the sale of other tropical fruits.

Obviously the tropical fruit with the greatest sale in processed form in this country is the pineapple, the main countries supplying being the USA, Australasia, Malaya, South Africa and to a smaller extent China and Ceylon. The packed figure in 1968 from South Africa alone was over two million cases, a large part of which came to the UK. Among other types of tropical fruit at present selling on this market are mango halves and

slices, mostly from India and South Africa, the best of which is the Alphonso type from India which are packed in halves rather than slices. Indian mangoes, however, tend to be high in price and probably no more than 10,000 cases per annum are imported. The South African mango, while regarded by many as inferior in quality to the Indian, has about double the sale in the UK due to a substantially lower price. Another fruit currently increasing in popularity is the guava, the main producing areas again being India and South Africa. Again, the Indian guava does tend to be better in quality but much higher in price, resulting in the bulk of sales being of the South African variety. Other varities of tropical fruit selling in this country in smaller quantities at present are papaya (paw-paw), goldenberries and some small quantities of passion fruit from Africa and Australia, also arbutus from China and Taiwan. Some packers also offer the juices or nectars from these fruits packed in cans. In considering the development of these lines, I believe there would be scope for increasing sales of a tropical fruit salad containing three or more fruits, including pineapple, packed in small retail packs.

Taking tropical and subtropical products other than fruits, enjoying an increasing popularity in this country are bamboo shoots and water chestnuts, coming mostly from China, Taiwan and Hong Kong. There is also an increasing demand for red and green peppers in small packs.

It is important that anyone contemplating the development of such business with the UK should be fully informed on such matters as labelling regulations and the need for strong packing of the tins and cartons to avoid damage in transit to, and during the course of distribution within, the UK. I will refer to this in greater detail later.

In considering the development of trade in preserved tropical products it must be recognised that the UK market, which is probably the largest single market for imported foods in the world, demands an increasingly high standard of quality in the products imported. The shipment of sub-standard qualities to the UK can only involve all concerned in substantial claims and losses.

From the canners' point of view, the simple truth that no end product of the cannery can be better than the raw material used is often overlooked. Packing high quality fruits must always be preceded by the careful grading of the raw material available, for size, colour, ripeness and freedom from blemish. It is also a matter of the greatest importance to food preservers that there should be an adequate supply of raw materials grown within reasonable distance of the factory, also that where seasonal products are concerned that other suitable crops are grown which will extend and ensure the fullest possible use of the factory staff and plant capacity.

Where a crop is dependent on seasonal rains the growing of crops on land capable of irrigation is necessary to ensure availability of raw materials.

Most food factories employ their own agronomists and horticultural advisers to assist growers with the provision of suitable seed, and with advice on soil conditions, use of insecticides and fungicides etc. Before starting any new enterprise it is usual to conduct seed and growing trials to determine quality and yield per acre, without which no accurate feasibility study can be undertaken.

Choosing the correct plant and equipment is very important. Despite the possibility that adequate labour may be readily available it has been my experience that the best commercial results can be obtained by having the production lines as fully automated as possible, while to achieve a steady flow of production conveyor belts, hoppers etc. are desirable. Plant purchased from the UK can often be provided if required on a 3 to 5 year credit, subject to acceptable guarantees. Companies such as my own specialize in this field and are often capable of finding markets for a substantial part of the factory output. This provides a fairly rapid return to the country concerned of the foreign currency expended on the plant.

Every food factory must be planned with maximum hygienic conditions, with tiled walls and floors, insect catchers, air conditioning, etc. Other speakers may enlarge on this subject but it must be regarded as a prerequisite for every good food factory.

A large number of products offered to this market by food processing factories suffer from production faults, the most common of which are:

(a) inadequate grading or quality of raw materials.

(b) mixing good and poor quality fruits in the same can—such parcels can only fetch the price of the lowest quality and are most difficult to sell.

(c) over and under sterilization—understerilization resulting in some blown tins can often make a complete shipment unsaleable.

(d) use of cans of incorrect size or cans which are unsuitable lacquered.

(e) using incorrect syrup strengths.

(f) packing fruits that have been allowed to lie far too long after picking.

(g) incorrect and faulty labelling and packing.

Quality control at all stages of factory production is essential for producing a high quality pack. This work cannot be left to chargehands, night shift foremen, etc. and production must be organized in such a way that competent quality control staff are always on duty during production runs.

Each factory must have a laboratory suitably equipped to carry out constant tests of samples off the line. Code numbers on cans relating to particular runs must be carefully recorded.

These may seem to be simple matters of commonsense but most production troubles start with a failure to control one or more of these factors.

The three basic ways of preserving food are by canning, freezing or dehydration. Canning is normally the most suitable for tropical fruit and juices but the possibility of dehydration should not be overlooked. We have developed a substantial trade in quality dried bananas from Ecuador and in my opinion there is great scope for this method of preserving fruits and vegetables. Freezing is an excellent method of preserving some foods but

has the disadvantage of high initial capital outlay coupled with transport problems and relatively high freight charges. Nevetheless, there is a great and growing demand for frozen foods in the UK and European markets.

The marketing of preserved foods in the UK is now highly complex. It is usually better for a manufacturer to have a sole distribution arrangement with a company on whom he can rely for correct advice on such matters as can sizes, packaging, accurate estimation of requirements, labelling, etc. Such a company must have an organization capable of nation-wide distribution, also with outlets to other European countries if possible.

The sale to many different importers, even if under their own or buyer's labels, creates price competition and a great deal of time is wasted offering similar goods to the same set of buyers. The reaction of large buyers to a multiplicity of offers from the same factory is usually that they will not commit themselves to any substantial purchase in case their competitors are able to buy more cheaply and so undercut their selling prices.

The various levels of distribution in the food trade today are as follows:

Importer: Responsible for negotiations with the overseas factory, arranging contracts, shipment, payment, sales and acceptance of legal responsibility that all UK regulations are complied with.

First Hand Distributor: Buys normally from an importer in substantial quantities and has his own distribution arrangements to the wholesale and multiple trade. There is an increasing tendency for these two functions to be combined in a single importer/distributor.

Wholesale Grocer: Buys imported goods in smaller quantity from an importer or first-hand distributor and sells in his local area to private shops, either delivering the goods at regular intervals or operating one or more cash and carry warehouses to which buyers from retail shops can make visits with their own transport and take up their own requirements. Large wholesalers often have in addition their own chain of shops or supermarkets.

Multiple Groups: Buy directly from importers or first-hand distributors to service their own chains of shops or supermarkets.

Wholesalers and multiple groups seldom buy imported foods directly from overseas: they do not normally have any staff competent to deal with imports, nor do they wish to accept the responsibilities of the importer.

All selling requires publicity of one kind and another in support of the salesmen who call on customers. In the food trade this takes a variety of forms, some of which are as follows:

National advertizing—taking space in national daily and Sunday papers, or television programmes. This is very expensive and only suitable for well-established lines after the goods are actually in the hands of retailers.

Trade advertizing—in weekly food trade papers. Useful for introducing new lines and trade brands.

Local advertizing—suitable for test marketing in selected areas in support of orders received.

Trade Fairs and Exhibitions—useful for displaying goods direct to the retailers and their customers. Support can often be secured from Government publicity services where the products of a particular country are being displayed.

Trade Promotion—usually arranged with large groups by giving a promotional discount on the normal selling price to encourage special displays in shops and supermarkets.

Point of Sale Display Advertisements—a further encouagement to retailers to produce special displays in their stores.

Appropriations for publicity suitable for the volume of trade can often be arranged between a factory and an importer on the basis that the factory makes a percentage allowance on each case ordered and the importer subscribes an equal amount from his profit on sales.

Canned goods are often shrink-wrapped to provide small buyers with the opportunity to take less than one carton in order to build up sales. This is of increasing importance to the trade and shrink-wrapped goods in multiples of one dozen tins wrapped in each papier-maché tray, 2 to 4 trays per carton, wrapped in clear cellophane have a higher potential sale than normal carton packs.

In January 1971 new regulations come into force in the UK relating to the labelling and description of goods. Exporting factories are advised to familiarize themselves with these new regulations.

Discussion

Dr. Thio: What are the prospects for processed tropical fruits in Europe? If they are sufficiently good, which fruits will give the best possibilities? Will it be possible to make the price competitive? What are the technological requirements to reach this?

Mr. Cave: This is a very difficult question, as volume plays an important part. In other words, if the volume you can produce is small, of a particular variety, then this may not be a viable product. I believe that any processing organization must take into account more than one product and also products which can be grown, although not necessarily being grown at the present time, which will fill in capacity at the factory at the time when seasonal products are not available. One can only generalize and say that one has to look over the whole possibilities of production of various types of fruit in order to get the longest continuous run into the factory.

Mr. Odoi: What facilities does the Fruit and Vegetable Trade Federation offer a developing country which wants to carry out a market survey or to assess the size of the UK market either for completely new tropical fruit or for a new variety of a tropical fruit which is already on the UK market?

Mr. Candia: As regards the Federation, it would be rather difficult for them to carry out a survey but there are other bodies, including the Ministry of Overseas Development who would be glad to assist. If you would specify the type of product you have in mind, they would assist I am sure.

Dr. Spensley: In fact, there is in the Tropical Products Institute an Economics Division which includes a Marketing Section, and it is one of its functions to provide answers to the type of question that you have just posed.

Mr. Mulherin: There are one or two general observations I would like to make on the various papers. On Professor Aylward's paper, I agree entirely except with one general point. Such work as we have done on the possibilities of establishing processing plants in developing countries suggests that local demand for processed fruit tends to be extremely limited for two reasons. Firstly, the history of canning shows that a certain sophistication of taste is required: generally, developing countries have not reached this level of sophistication. I do not feel that the market is therefore viable. Secondly, there is the question of cost. Even if the latent demand is present, it has not yet been possible to produce a product which is cheap enough to be purchased by most consumers in a developing country. This has been found in many cases. Therefore, such research as we have undertaken is based on the assumption that most processed fruit is for the export market.

On Mr. Cave's very elegant paper, I am in full agreement that the underlying assumption may well be right and that to produce for export, with the quality control that he desires, large scale enterprises are required. Enterprise has to be sufficiently large to carry this important cost item. I disagree with the possibility of markets expanding for dried banana consumption. An excellent paper by Mrs. Kay of TPI showed that there appears to be no enlarged future for these products. Our last financial study meeting in Panama came to the conclusion that trade in this product had not been growing very substantially and this has been supported by my own observation. The processed item which does offer some future is banana purée, but even here there is no really substantial market. It might take a few thousand tons of bananas off the market, but in Ecuador, with a million tons surplus, what effective difference does this make?

Mrs. Kay: At the beginning of this year, in Iran, Pakistan and Turkey, we discovered that only 2% of the local population can afford to buy canned fruits. The local market is very limited, and one must concentrate on export markets. For any potential processing industry there must be one sound major item. Then they can develop speciality items. Another point, on the contractual method of buying raw materials. At least in the three countries mentioned this came out as the key factor handicapping the industry: lack of raw materials and inadequate maintenance of grades. There is another point which might interest members of the countries producing grades of different products. The benefit of

loans from banks on canned goods can often be obtained, but only for the first grade. They can usually obtain 60% of the market value on this. Until the cannery can produce various grades it is very difficult to obtain capital or advances. Small developing canneries should investigate this.

Second Session

Monday 15th September
Afternoon

Chairman
Mr. J. Candia, President
London Fruit and Vegetable
Trades Federation Ltd.

Le commerce des fruits tropicaux dans le Marché Commun

R. M. Cadillat
IFAC, Paris, France

Résumé

La part prise par les agrumes et fruits tropicaux est indiquée dans une revue de la production mondiale fruitière. Les grandes lignes du commerce international, exportations, importations des oranges, mandarines, pomélos, citrons, bananes, ananas sont étudiées, avec leur évolution des dernières annees.

Egalement, l'évolution des autres fruits tropicaux: avocats, mangues, litchis, mangoustans est examinée en ce que concerne le Marché Européen.

Des études séparés sont donnés des divers secteurs du Commerce Européen, tels que la Communauté Economique Européene, la Communauté de l'Association Economique de Libre Echange, les autres Pays de l'Europe occidentale et de l'Europe orientale.

Le commerce d'un fruit ne pouvant être étudié séparément, on rappelle ce qu'a été l'évolution des autres fruits concurrents sur les marchés et leur tendance.

Ne se basant que sur l'évolution de la population, exception faite des autres considérations tels que les prix, les revenus, les facteurs politiques, on examine ce que pourrait être en 1975 et 1980 la consommation de ces fruits.

Que représentent tout d'abord les Fruits Tropicaux, agrumes y compris dans la Production Mondiale?

D'après le dernier annuaire paru de la FAO, celui de 1967 qui donne une production mondiale de fruits frais de 1966, celle-ci, à l'exclusion des amandes, noix et raisins à cuve, s'élève à 58,400,000 tonnes sur 112,100,000 tonnes, alors que l'ensemble des céréales représente 1,087,000,000 tonnes et la canne à sucre 511,000,000 tonnes, les pommes de terre 137,000,000. Dans les bananes 23,700,000, T sont inclus les plantains. La banane desserte ne doit représenter que 6 à 8,000,000 T. Ce qui fait en gros non compris les plantains de 5. 3 à 7. 1 %, 27. 68 % pour les agrumes, 3. 23 % pour les ananas.

Dans les annuaires statistiques FAO ne sont pas donnés tous les pays ni les autres fruits tropicaux, tels les avocats, ni les mangues dont la seule production de l'Inde se situe à 3,000,000 de tonnes.

Quant à nous nous estimons la production mondiale de tous les fruits comme se situant à 130/150,000,000 de tonnes.

Pour ce qui est du Commerce mondial des fruits la FAO ne donne que certains fruits sur le total de 13,000,000 de tonnes exportées, les agrumes représentent 35. 3 % (4,600,000) et les bananes 39. 6 % (5,170,000).

La place des fruits tropicaux est variable dans l'importation des différents pays. Le maximum se situe au-dessus de 90 % (tels les Etats-Unis et l'Italie), le minimum entre 50 et 60 %, tels entre autres URSS 51 %, Allemagne Fédérale 56. 8 %.

Mais il est intéressant de noter que si l'on considère la consommation apparente (Production + importation moins exportation ou réexportation) de tous fruits frais par tête d'habitant, on constate que la part des fruits tropicaux va de moins de 20 % par exemple en Suisse à plus de 50 %, tels l'Angleterre 52 % ou les Etats-Unis 59. 5 %.

Dans les pays de l'Europe orientale et en URSS la part des Fruits tropicaux est inférieure à 5 %.

Dans les pays de la CEE on constate qu'au cours des dernières années la part des agrumes et des bananes, les autres fruits ne représentent que quelques dizaines de grammes ou une ou deux centaines pour l'ananas par tête et par an, présente une certaine constance 21 % pour les agrumes et 8 % pour les bananes. Ces deux fruits avec

les pommes représentent les 2/3 de la consommation des fruits frais par tête et par an dans cette entité économique.

Nous examinerons séparément ce qu'il en est de chacun des fruits tropicaux.

La Banane

Elle vient en tête du Commerce International 5,170,780 tonnes en 1966 contre 4,609,000 tonnes en 1965, d'après le dernier annuaire FAO pour les exportations.

En 1968, d'après le Groupe d'Etudes FAO elles ont été de 5,700,200 tonnes et 5,526,000 tonnes d'importations. Pour les agrumes, pour la campagne 1967/1968 les exportations avaient été de 4,544,000 tonnes.

La banane plus qu'aucun autre produit subit l'influence des transports.

Les tableaux 1 et 2 montrent ce qu'a été le Commerce Mondial au cours des dernières années. La part prise par chaque zone productrice montre l'évolution de 1966 à 1969 et les conjonctures FAO pour 1972 (tableau 3). On constate que l'Amérique Centrale a actuellement repris ou presque sa prépondérance d'avant-guerre avec 36. 6 % en 1968, soit 50 % d'augmentation sur la moyenne 1962/1964. A part l'Asie les autres zones voient leur participation en régression. Ceci est la conséquence en particulier de la reconversion en nouvelles variétés. Pour l'Amérique Centrale comme pour l'Amérique du Sud, la banane alimente pour la moitié ou plus les rentrées financières du Commerce Extérieur.

En ce qui concerne les importations, les Etats-Unis ont pris 30. 4 % contre 33. 4 % en 1962/1964. Ils ont perdu la prépondérance d'avant guerre où ils prenaient 75 % de plus que l'Europe. Actuellement c'est l'Europe, non compris les pays de l'Europe orientale qui importent 50% de plus que les Etats-Unis. La CEE importe avec 1,497,000 tonnes 27 % du trafic mondial, l'AELE 11. 5 % avec 637,800 tonnes. La part de la CEE est sensiblement en pourcentage la même qu'en 1962/1964, 27. 6 %, mais en légère repression sur les années précédentes. L'AELE l'est aussi. Mais les 3 entités: Etats-Unis, CEE, AELE prennent les 2/3 du commerce mondial, 68. 9 % contre les 3/4 en 1962/1964. C'est la conséquence de l'accroissement spéctaculaire du Japon devenu deuxième importateur mondial, avec 637,800 tonnes, 11. 5% contre 6. 7% en 1962/1964.

Si l'on prend la consommation par tête, de ces trois entités économiques c'est l'américian qui vient en tête avec 8,366 kg pour les pays importateurs, suivi par l'Europe én membre de la CEE 8,023 kg, celui de l'AELE 6,721 kg, le Japonais 6,308 kg. Mais parmi les autres consommateurs de bananes l'Espagnol consomme 10,755 kg, l'Allemand 9,418 kg, la Suisse 9,720 kg, le Norvégien 9,317 kg, le Nouveau Zélandais 10,359 kg.

Dans le commerce mondial que l'on sent être en pleine évolution, pour ne pas dire mutation, il est intéressant pour nous autres Européens et ceux qui approvisionnent nos marchés, d'avoir un aperçu des courants commerciaux.

Aux Etats-Unis le marché est libre, mais dominé par deux grandes Compagnies qui importent plus de 90 % (United Fruit 56 %, Standard 31 %) ce pays reçoit ses fruits pour 78. 8 % d'Amérique Centrale et 20. 6 % d'Amérique du Sud.

En Europe où les régimes d'importation sont différents, non seulement à l'intérieur de chaque entité économique, mais encore à l'intérieur de celle-ci comme la France (Pays producteur) et l'Angleterre, bénéficie d'un régime préférentiel où l'Espagne et le Portugal qui n'importent pas de l'Etranger étant producteurs.

C E E Les importations sont réglementées par le Tarif extérieur commun, 20 % ad valorem, pour les provenances des Pays tiers, exception faite de l'Allemagne qui bénéficie d'un protocole annexé au Traité de Rome, et d'un tarif spécial pour les pays membres associés. En 1968 sur 1,496,782 tonnes importées 37. 9 % provenaient des pays membres et associés, 567,829 tonnes dont 18. 6% de France; 25. 4% d'Amérique Centrale dont 17. 9% du Honduras; 35. 1 % d'Amérique du Sud dont 23. 9 % d'Equateur. Le principal client est l'Allemagne qui sur son tonnage reçoit 47. 5 % d'Amérique Centrale et 40. 7 % d'Amérique du Sud. Le Bénélux recoit 12. 7 % d'Amérique Centrale, 85. 2 % d'Amérique du Sud Les Pays-Bas 88. 8 % d'Amérique du Sud et 4, 2 d'Amérique Centrale, L'Italie 29. 2 % d'Amérique Centrale et 24 % d'Amérique du Sud. La France a pris moins de 2 % de ces provenances.

A E L E Pour ces pays sauf en Angleterre où la préférence est donnée aux importations de la Zone sterling et fixe un quota pour la Zone dollar, l'importation est libre, mais avec un droit de 15 % ad valorem environ pour les pays non membres du Commonwealth. Les importations proviennent en presque totalité de Jamaique et des Windwards Islands, 96. 4 % des importations totales de 1968, 97. 1 % en 1967.

Pour les autres pays membres, à l'exception du Portugal qui reçoit en totalité ses fruits de sa province de Madère et de ses territoires d'Afrique, les provenances viennent à plus de 96 % d'Amérique Centrale et du Sud.

Pour les autres pays d'Europe, non membres de ces entités, c'est l'Afrique le principal fournisseur 85. 4 % pour la Finlande, la Grèce, la Yougoslavie en gros moitié entre l'Afrique et l'Amérique du Sud.

Que sera le commerce d'ici quelques années et quelles seront les possibilités de débouchés?

En ces temps modernes nous n'avons plus de pythies à moins que les ordinateurs ne remplacent les oracles.

Il est fort ardu de dire comment va se transformer le commerce bananier. La mutation en cours a déjà commencée il y a quelques années par les exportations en mains de bananes et non plus en régime, par navires spécialisés réfrigérés, en cartons. Ce mode de transport ne va-t-il pas être remplacé par des containers réfrigérants ou autres ne nécessitant plus les reefers, ou tout simplement par le transport aérien qui pourrait supprimer le stade des mûrisseurs.

Un autre aspect de l'évolution sera le problème des prix de revient devant la surproduction existante risquant de faire disparaitre certains producteurs devant la compétitivité de plus en plus accrue, si des mesures ne sont

Table 1

Exportations Bananieres

	1964	1965	1966	1967	1968	1969 forecast
TOTAL GENERAL	4,346,720	4,764,780	5,170,780	5,523,500	5,700,200	6,418,900
dont:						
CENTRAL AMERICA						
British Honduras	410	2,010	4,940	2,800	3,700	4,000
Costa Rica	293,690	316,040	358,740	371,000	480,000	650,000
Guatémala	111,010	58,000	76,730	105,600	142,500	200,000
Honduras	349,000	571,560	709,940	824,800	884,800	920,000
Mexico	17,070	14,340	11,880	6,900	10,000	10,000
Nicaragua	27,150	7,960	13,550	35,400	45,000	45,000
Panama	266,620	335,540	385,550	454,000	524,000	575,000
SOUTH AMERICA						
Bolivia	640	470	590	1,100	1,000	1,000
Brazil	225,540	215,750	204,810	170,900	160,300	220,000
Colombia	171,570	253,460	341,910	325,600	294,600	380,000
Ecuador	1,382,700	1,200,000	1,264,800	1,262,400	1,252,500	1,300,000
Surinam	2,800	13,620	13,060	21,800	35,100	40,000
Venezuela	11,350	13,350	20,060	1,000	1,200	1,200
AFRICA						
Cameroon	115,700	119,090	70,000	48,200	44,800	48,000
Congo Léo	13,350	7,030	7,120	..	..	..
Ghana	2,200	1,250	500	600	500	500
Guinea	30,000	24,900	25,000	32,200	30,000	33,000
Ivory Coast	125,930	116,770	127,000	131,900	136,000	130,000
Madagascar	14,460	18,300	33,220	21,000	25,000	25,000
Portugal (Angola)	3,240	3,620	5,810	..	..	..
" (Cape Verde)	3,110	3,390	4,030	..	..	..
" (Madère)	..	..	..	32,000	35,000	35,000
" (Overseas Prov.)	..	..	..	24,500	20,000	20,000
Somalia	104,830	99,280	93,890	82,200	85,000	100,000
Spain (Canary)	112,690	103,290	89,470	366,700	349,100	400,000
ASIA						
China	17,040	18,990	32,250	25,000	18,000	30,000
China (Taiwan)	200,980	337,390	370,350	426,800	385,500	450,000
India	8,230	8,130	12,000	6,000	8,000	10,000
Israël	13,340	17,210	21,240	21,300	14,300	15,000
Jordan	1,420	4,720	7,740	5,200	5,000	5,000
Lebanon	13,870	9,050	10,570	10,000	9,000	9,000
Philippines	100	100	100	400	3,500	24,000
Thailand	3,470	7,620	4,080	4,000	4,000	4,000
CARIBBEAN						
Domin. Rep.	69,080	48,020	10,620	10,000	10,000	10,000
France (Guadeloupe)	54,810	78,200	92,000	78,000	101,000	97,000
(Martinique)	85,990	177,720	207,480	192,700	186,000	200,000
Grenada	11,570	20,980	18,920	..	..	..
Haiti	110	400	110	7,000	7,000	5,000
Jamaica	177,200	203,010	203,630	194,500	155,600	180,000
St. Lucia	61,240	81,650	76,620	..	..	..
St. Vincent	25,450	28,850	25,370	..	..	..
Windward Islands	..	..	..	164,200	185,000	205,000
OCEANIA						
Fiji Islands	4,010	1,650	4,000	1,600	3,500	4,500
Tonga	5,350	10,740	15,490	20,700	17,000	17,000
Western Samoa	21,100	15,730	2,020	3,100	3,500	3,500

Table 2

Importations Bananieres

	1964	1965	1966	1967	1968	1969 forecast
TOTAL GENERAL	4,135,770	4,683,290	4,983,350	5,401,900	5,526,200	5,741,900
dont:						
NORTH AMERICA AND CARIBBEAN AREA						
Canada	152,300	167,000	174,910	181,900	194,300	204,000
United States	1,448,320	1,565,350	1,617,600	1,638,400	1,683,000	1,716,000
Other (Barbados-Netherlands Antilles)	3,900	4,800	..	3,900	4,800	4,800
SOUTH AMERICA						
Argentina	167,020	190,560	173,310	143,400	140,000	140,000
Chile	28,500	28,170	49,340	75,400	74,600	76,000
Peru	5,320	4,760	4,190	3,300	5,000	5,000
Uruguay	29,950	24,110	24,130	..	..	..
AFRICA						
Algéria	17,700	24,620	18,000	18,000	11,000	12,000
Morocco	8,150	8,550	10,320	9,600	10,000	10,000
South Africa, Rep.	10,580	7,390	5,910	5,800	6,000	6,000
Tunisia	2,560	1,070	1,410	..	..	..
ASIA						
Hong Kong	17,200	18,250	29,190	22,500	21,000	25,000
Iran	620	4,540	2,770	..	..	..
Iraq	6,110	5,330	6,470	5,500	6,000	6,000
Japan	351,850	357,610	416,250	481,100	637,800	650,000
Jordan	1,550	3,330	1,960	..	..	..
Singapore	23,540	20,520	19,910	19,700	17,000	15,100
Syria	9,300	4,780	7,440	8,100	8,000	8,000
EUROPE						
Austria	39,630	47,570	56,520	55,800	50,000	53,000
Belgium Luxembourg	67,910	79,680	98,270	93,100	80,000	90,000
Bulgaria	370	590	150	300	600	..
Czechoslovakia	7,130	14,040	17,790	20,100	..	..
Denmark	33,230	33,010	38,520	43,400	41,100	41,100
Finland	15,150	16,250	16,470	16,600	16,000	16,000
France	352,690	399,280	460,400	444,000	430,700	445,000
Germany, Fed. Rep.	487,010	585,000	606,230	605,200	565,900	596,000
Germany, Eastern	15,500	15,000	20,000	28,000	..	..
Greece	6,210	8,490	10,130	13,400	13,700	13,700
Hungary	670	980	1,450	4,600	12,300	..
Iceland	970	1,010	1,170	1,300	1,200	1,200
Ireland	14,090	17,100	17,890	19,500	19,500	21,000
Italy	163,610	316,560	322,380	318,600	322,400	315,000
Malta	1,260	930	1,360	1,800	1,200	1,200
Netherlands	68,100	81,320	99,560	100,200	97,900	100,000
Norway	27,450	33,110	34,790	36,600	35,500	35,500
Poland	800	1,330	3,210	3,200	..	..
Portugal	5,940	6,780	7,600	32,000	35,000	37,000
Romania	..	110	..	300	1,800	..
Sweden	45,370	53,330	57,330	66,300	70,000	72,000
Switzerland	54,270	56,100	60,820	59,400	59,300	60,000
United Kingdom	352,520	376,300	369,210	353,300	346,700	365,000
Yugoslavia	8,050	14,540	20,350	37,500	36,200	40,000
URSS	18,200	23,400	21,900	18,500	..	..

	Moyenne				Prévisions %		
	1962/64	1966	1967	1968	1969	1972	
						min.	max.
Amérique Centrale	24.5	29.	32.5	36.6	37.4	42.2	45.
Amérique du Sud	38.5	34.2	32.2	30.6	30.2	26.	23.9
Afrique	14.6	14.9	13.9	13.1	12.7	11.	10.5
Antilles	17.7	12.8	11.7	11.3	10.8	10.2	10.2
Asie	3.7	8.5	9.	7.7	8.2	9.9	9.5
Océanie	0.7	0.4	0.4	0.4	0.3	0.4	0.5

pas prises. Il en sera de même, compte tenu du maintien ou non de certaines mesures dites restrictives au commerce, selon la théorie du Libre Echange.

Ces dernières questions ont fait l'objet des discussions de la dernière réunion du Groupe de la FAO sans y trouver une solution pour un avenir rapproché.

Quoiqu'il en soit on peut toujours essayer de se faire une idée de ce que demain sera. Il serait plus exact de dire que suivant sa propre optique chacun se fait son idée.

A la lumière des chiffres des années passées et basées uniquement sur le taux d'accroissement de la population variable suivant les sources ONU, OCDE, CEE, voici ce que nous pensons que pourraient être les tonnages à importer en 1975 et 1980, après avoir envisagé 5 hypothèses:

(a) consommation égale à celle de 1967 pour chaque entité économique,

(b) consommation par tête au maximum de chaque entité,

(c) tous les pays consommant 9 ou 10 kg par tête,

(d) taux augmentation identique de 1967 à 1975 et 1975 à 1980 à celui de 1967 sur 1965.

(e) taux annuel d'augmentation de 1, 2 ou 5 %.

on aurait:

	Hypothèse faible			Hypothèse forte		
	1975		1980	1975		1980
Pour la CEE	1,720,000		1,800,000	1,850,000		2,000,000
AELE		720,000			850,000	
Autres Europe		500,000			600,000	
Europe Est		250,000			400,000	
Etats-Unis		2,000,000			2,500,000	

La perspective à moyen terme du Secrétariat de la FAO (doc CCP BA 69/3) prévoit pour 1972, en fonction du prix constant jusqu'à une baisse de 30 %, une conjoncture:

- pour la CEE se situant entre 1,701,000 et 2,185,000 tonnes,
- pour l'AELE entre 671,000 t et 804,000 t non compris le Portugal,
- pour le reste de l'Europe occidental de 530,000 t à 666,000 t
- pour les Etats-Unis entre 1,737,000 t et 2,300,000 t.

Ces chiffres quant à moi me semblant trop optimistes. Dans quatre ans nous serons fixés sur la réalité pour cette conjoncture. Dans 6 ans pour celle de 1975. Espérons que nous serons tous encore en ce bas monde pour voir ce qu'il en sera et de combien sera l'erreur des pronostiqueurs.

Les Agrumes

Le groupe Agrumes FAO estimait en Avril dernier la production à 28,575,000 tonnes en 1967 contre 31,139,000 tonnes en 1966, 26,807,000 tonnes en 1965. Mais cette prévision préliminaire de 1968 ne comprend que les seules oranges d'hiver 19,285,000 tonnes contre 17,328,000 tonnes en 1967, soit une augmentation de 11. 2 %. En prenant pour l'ensemble des oranges une augmentation de 10 %, la production d'agrumes de 1968 devrait se situer autour de 31,400,000 tonnes, légèrement supérieure à celle de 1967.

Pour les agrumes il y a une différence avec les bananes, c'est celui des deux hémisphères qui joue surtout pour les oranges, mandarines et clémentines, dont 23. 8 % sont produits au Sud de l'Equateur.

Oranges, Mandarines, Clementines

C'est le Bassin Méditerranéen la principale zone productrice avec 32 %, 7,438,000 tonnes non compris la Turquie, avec ce pays 34. 4 %. Viennent ensuite les Etats-Unis avec 22. 9 %, 5,333,000 tonnes. Ces deux zones représentent plus de 50 % de la production mondiale. L'Afrique du Sud, le Brésil, l'Argentine, l'Australie représentent 19. 1 %.

En gros moins de 20 % des agrumes produits sont exportés, 31 % en gros de la consommation sur place va à la transformation.

Pour les importations, d'après le dernier annuaire de la FAO (1967) en 1966.

L'Europe a pris	83. 8 %	dont:	53, 5 % à la CEE
			22, 1 % à l'AELE
			3, 8 % à l'URSS
L'Afrique	0. 3 %		
L'Amérique du Nord	6 %		
L'Asie	5. 4 %		
L'Océanie	0. 5 %		

La CEE a importé 1,810,997 tonnes en 1968 contre 1,943,370 tonnes en 1967 soit une régression de 6. 7 %, mais en augmentation de 13. 4 % sur 1961. Le principal fournisseur est le Bassin Méditerranéen avec 88 % (85. 7 % en 1967). L'Amérique du Nord 0, 4 % contre 3. 6 %, l'Afrique 6. 9 % contre 6 %, l'Amérique du Sud 2. 3 % contre 2. 9 %. En gros on peut dire que les importations d'Afrique, d'Amérique du Sud et du Nord sont celles d'oranges d'été.

Il ne faut pas perdre de vue, pour la consommation des fruits exotiques l'augmentation de la production des fruits métropolitains, en particulier des pommes et des baies.

D'aprés nos estimations et suivant plusieurs hypothèses: consommation identique à 1965 ou 1967, taux augmentation de 10 %, ou taux augmentation annuel de 1. 2 ou 5 %. En 1975 les importations de la CEE devraient se situer autour de 2,250,000 tonnes. En 1980 autour de 3 millions de tonnes, projection basée uniquement sur l'accroissement de la population.

Pays AELE, les importations de 1968 avec 805,422 t marquent une legere regression sur 1967, mais de 11. 6 % de plus qu'en 1961. Le principal fournisseur est le Bassin Méditerranéen 77. 3 % en 1967, suivi par l'Afrique (Afrique du Sud presque exclusivement) 2. 3 % d'Amérique du Nord, 3. 3 % d'Amérique du Sud. En gros cette entité prend 20 % d'oranges d'été contre 10 % à la CEE.

En 1975 la consommation pourrait être 900,000/950,000 t Portugal non compris et en 1980 autour de 1,200,000 t.

Autres pays, non compris les pays producteurs: Espagne, Grèce, les importations proviennent à 87 % du Bassin Méditerranéen et 10. 9 % d'Afrique du Sud et du Brésil. En 1975, leur consommation pourrait être autour de 220,000 tonnes et en 1980 de 250,000 tonnes. Pour les pays de l'Europe Orientale y compris l'URSS dont la plus forte consommation par tête en 1967 a été la Tchécoslovaquie avec 2. 7 kilo. Nous mettrons la consommation en 1975 de 300,000 et 500,000 tonnes.

Citrons

La production y compris les limes aurait été de 3,085,000 tonnes en 1967 contre 2,994,000 t en 1966 d'après le Groupe Agrumes de la FAO (avril 1969). La part du Bassin Méditerranéen a été de 39. 1 % en 1966 dont 21 % pour l'Italie qui, avec les Etats-Unis est principal producteur 22. 9 %.

Par rapport à 1961, l'augmentation de la production a été de 18. 9 % en Italie, 12. 9 % aux Etats-Unis. Environ 18 % de la production va à l'Industrie de transformation.

C'est l'Europe le principal client comme pour les oranges 81. 7 % en 1966, dont 39. 7 % à la CEE, 14. 3 % à l'AELE, URSS 8. 2 %, Amérique du Nord 3 % Afrique 0. 07 %, Asie 6. 7 %. La part de la CEE a diminué plus fortement que celle de l'AELE depuis 1961. La part des de l'Europe orientale (27. 9 %) a plus que doublée sur 1961. Mais si le pourcentage de participation a diminué, le tonnage a augmenté de 2. 5 %, sensiblement le même pour la CEE et l'AELE à fin 1965.

Dans la CEE c'est en France et aux Pays-Bas que l'augmentation a été la plus sensible depuis 1961 et sur 1965, alors que l'Allemagne est en régression. L'Angleterre a une consommation stationnaire.

Pour la CEE 83 % de l'approvisionnement vient du Bassin Méditerranéen, 15 % des Etats-Unis, 0. 3 % d'Afrique du Sud.

Pour l'AELE 78 % du Bassin Méditerranéen, 14. 4 % d'Amérique du Nord, 3. 8 % d'Afrique du Sud.

Il en est de même pour les autres pays, le Bassin Méditerranéen est le principal fournisseur suivi des Etats-Unis.

Pour 1975 et 1980, suivant les mêmes hypothèses que pour les oranges, les importations de citrons dans la CEE, Italie non comprise, pourraient se situer à 270,300,000 tonnes pour 1975 et autour de 400,000 tonnes en 1980. Pour l'AELE autour de 110,000 tonnes en 1975 et 125,000 tonnes en 1975. Pour les pays de l'Europe orientale y compris l'URSS entre 65,000 et 120,000 tonnes.

Pomélos

C'est l'agrume le plus utilisé par l'Industrie de la transformation puisque 38 % de la production lui est destinée. La production mondiale a été de 2,291,000 tonnes en 1967. Les principaux producteurs sont les Etats-Unis 1,616,000 tonnes (2,081,000 en 1966) soit 70 % du total, Israël 220,000 t, Afrique du Sud 72,000, Argentine environ le même chiffre (79,950 t en 1966). Les antilles anglaises y compris Honduras Britannique 47,000 t, Chypre 36,000. Ces pays représentent 90 % de la production mondiale. Ce sont les principaux fournisseurs des pays importateurs qui ont pris 377,000 tonnes en 1967, dont 74. 4 % par l'Europe (CEE 39.7 %, AELE 30.1 % en 1966), Amérique du Nord 20. 5 %, Asie 3. 9 %.

L'augmentation de la consommation des pomélos a été très symptomatique surtout pour la CEE. Elle a plus que doublée de 1961 à 1968, sur 1965 l'augmentation est de 44 % avec 166,800 tonnes, alors que pour l'AELE avec 103,444 tonnes l'augmentation n'est que de 12 %. Pour les autres pays de l'Europe orientale leur importation a

quadruplé passant de 2,062 t à 9,104 t et pour les autres pays d'Europe Occidentale, elles ont doublé avec 5,500 t en 1966. Pour la CEE 76 % des importations proviennent du Bassin Méditerranéen dont 85. 1 % d'Israël. L'Amérique du Nord 8. 9 % sur les 24,955 t de cette provenance, 9,580 t des Etats-Unis. D'Afrique 8. 8 % sur 14,682 t, 14,207 t d'Afrique du Sud, 5,791 t d'Amérique du Sud, dont 3,746 t de Surinam. Pour l'AELE faute de parution des annuaires nous n'avons que 1967. 57. 9 % proviennent du Bassin Méditerranéen, 28. 8 % d'Afrique dont 19,308 t d'Afrique du Sud, soit 66. 4 % de la part africaine, 9. 4 % d'Amérique du Nord.

Nous fixerions pour 1975 une consommation de l'ordre de 200,000 t pour la CEE et pour 1980 de 280,000 à 300,000 tonnes. Pour l'AELE de l'ordre de 140/150,000 tonnes en 1975 et 170,000 t en 1980.

En matière d'agrumes, pour l'avenir, nous ne pensons pas à une modification importante des courants commerciaux, le Bassin Méditerranéen restant le principal fournisseur.

Il y aura moins de transformation sous l'angle commercial et technique de transport que pour la banane. Il s'agira surtout 'd' improvement' des services rendus par les Importateurs aux Producteurs Exportateurs.

L'Ananas

Il est difficile de fixer la production de ce fruit pour le Commerce International en frais, car sa culture est surtout faite en vue de l'Industrie de la conserve.

Sa production donnée par la FAO est passée de 3,204,000 tonnes en 1961 à 3,626,000 tonnes en 1966, soit 13. 1 % d'augmentation. L'Amérique du Nord, y compris Hawaï produit 34. 7 %, l'Asie 35. 4 %, l'Afrique 14. 7 %, l'Amérique du Sud 11. 9 %, l'Océanie 3 %. Le commerce international en frais représente environ 90,000 t, soit un peu plus de 2 % de la production.

Le principal importateur sont les Etats-Unis avec environ 40,000 tonnes, suivis de l'Argentine 23,571 t, le Japon 21,000 t, 30 fois plus qu'en 1961. La CEE avec 19,668 t en 1966, en 1968 21,494 t, 9. 8 % d'augmentation sur 1967.
Les principaux acheteurs sont la France 67 % avec 14,000 t l'Allemagne 20. 1 %.

La Côte d'Ivoire est le principal fournisseur de la CEE avec plus de 50 %, suivie des Antilles françaises 5,060 t, le Cameroun 1,040 t, le Brésil, 852 t; Guinée 907 t.

Pour l'AELE le principal client est l'Angleterre avec 5,617 t en 1968, 4,437 t en 1967. Elle prend 70 % des importations totales Le principal fournisseur est l'Afrique du Sud, 58 % du tonnage, le Portugal (Açores) 3,609 t, la Côte d'Ivoire et le Kénya, puis l'Amérique du Sud avec 50 t. Pour les autres pays d'Europe occidentale dont nous n'avons pas la ventilation, l'importation doit se situer autour de 2,000 t en 1966, la Yougoslavie à prés d'un millier de tonnes.

Les pays de l'Europe orientale doivent importer 2 ou 3 centaines de tonnes. L'URSS a importé en 1967, 3,048 t. Son seul fournisseur est la Guinée.

Que sera la consommation en 1975? Malgré l'augmentation notable de ces dernières années en CEE. Nous ne pensons pas que la consommation double, ni arrive à la consommation moyenne du français 228 gr par tete/an. Il faudrait alors 56,300 t. Nous pensons qu'elle se situera autour de 35,000 t. Pour l'AELE autour de 8,000 t 10,000 t maximun consommation moyenne égale à celle de l'anglais en 1968, 102 gr. L'URSS 5,000 t. Ensemble de l'Europe autour de 50,000 t.

Dans l'avenir nous pensons que l'Afrique du Sud et la Côte d'Ivoire maintiendrait leur prédominance actuelle, mais que la part des Antilles et des Pays d'Amérique du Sud sera plus importante ainsi que certains pays d'Afrique.

Les Autres Fruits Tropicaux

Parmi la gamme multicolore et variée de ces nombreux fruits, ce sont principalement l'avocat, ce fruit légume, les mangues qui constituent la majorité du Commerce International. Il est impossible avec les goyaves, litchis, mangoustes, passion fruit, 'chinese goose-berries' etc... d'en fixer même approximativement la production mondiale.

Sur nos marchés européens on considére vraiment ces fruits comme des fruits de luxes, surtout qu'ils sont presqu' exclusivement acheminés par avion et qu'ils sont très fragiles, ce qui augmente les prix de revient.

Dans la CEE, il a été importé 3,217 t en 1968 contre 2,133 en 1967. La France a pris 82 % avec 2,638 t.

Pour l'AELE les ventilations douanières ne permettent pas de connaître exactement leur tonnage. Les importations doivent se situer autour de 2,700 t. L'Angleterre a importé en 1968, 2,571 t contre 1,765 t en 1967. L'augmentation pour ces deux entités économiques a été similaire 50 % CEE, 45 % AELE L'avocat représente pour la CEE 85, 7 % des importations. La situation pour l'AELE, est identique.

Les principaux fournisseurs sont Israël 61 %, la France (Martinique) l'Afrique du Sud, le Cameroun, la Jamaique, la Côte d'Ivoire.

Le second fruit surtout importé est la mangue. Pour la CEE environ 300 t dont 221 t en France. Pour l'AELE 400/500 t. Les autres fruits doivent représenter pour l'Europe moins de 200 t. En France 58 t, dont 22 t sont fournis par Israël.

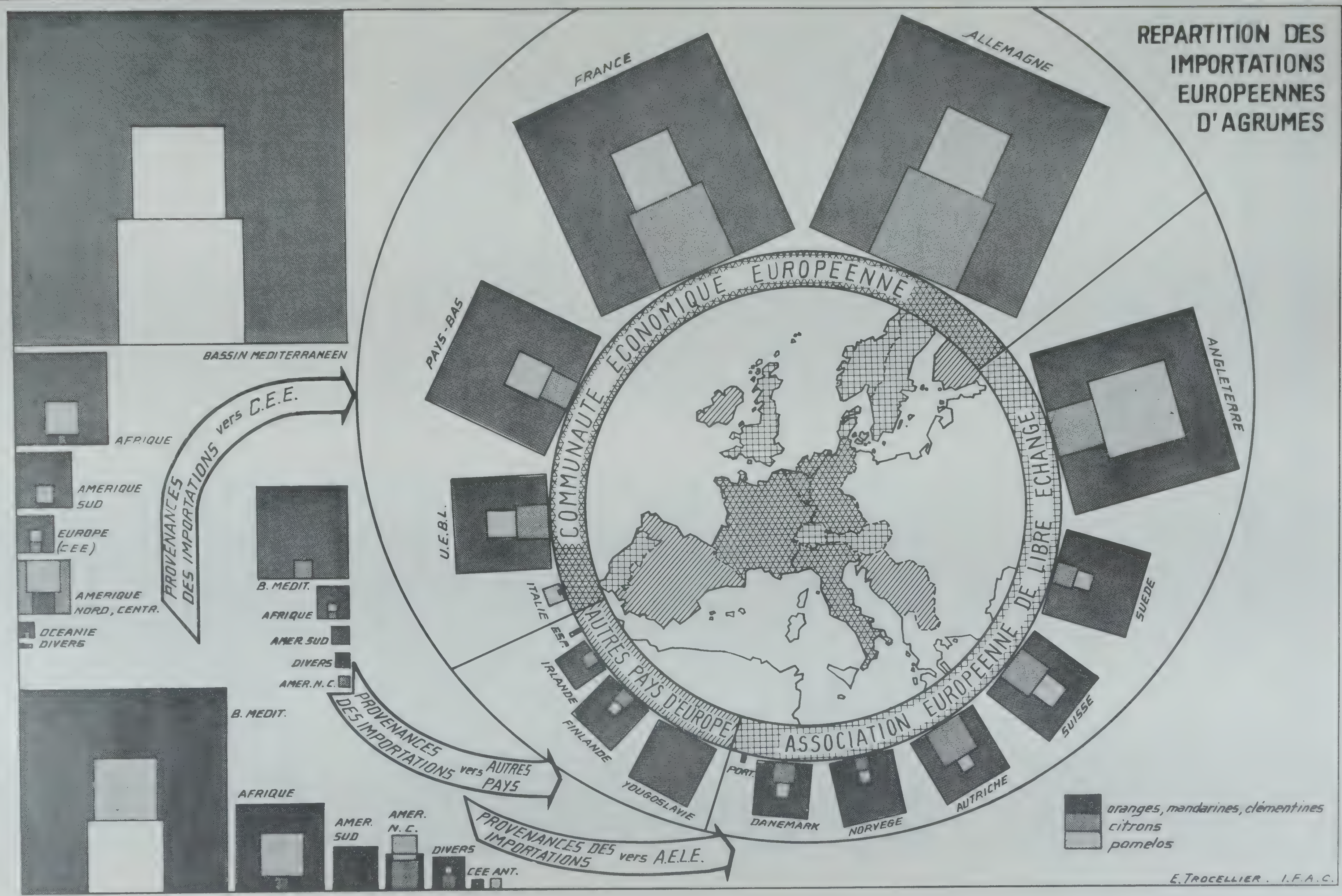
Quel sera l'avenir de ces fruits? Il est certain mais moindre que certains l'espèrent.

Le taux d'augmentation ne sera certainement pas identique à celui de 1968 sur 1967, car il faudrait alors importer 77,000 t en 1975. Nous pensons qu'il serait raisonnable de penser à un taux d'augmentation annuel de 10 % ce qui ferait que l'on peut escompter importer autour de 15/20,000 t, soit 3 fois à 4 fois les importations actuelles, dont environ 12,000 à 15,000 t d'avocats.

Pour ces fruits, comme pour tous, ce sera le facteur qualité qui sera primordial

Je vous ai donné ces indications, trop rapidement à mon gré, pour que vous puissiez avoir une idée générale, chacun suivant votre optique de producteur, d'importateur ou de grossiste. Mais j'aurais voulu vous mettre en parallèlle l'évolution des fruits métropolitains car un fruit ne peut être qu'étudié dans le contexte des autres fruits.

Je pense que ces chiffres, ces données rapides permettront de penser à ce problème de fruits tropicaux en se rappelant ce que disait ce mathématicien et philosophe français du 17° siècle, Blaise Pascal 'L'homme est visiblement fait pour penser, c'est toute sa dignité et tout son métier. Tout son devoir est de penser comme il faut'.



REPARTITION DES IMPORTATIONS EUROPEENNES D'AGRUMES
FRANCE
ALLEMAGNE
ANGLETERRE
PAYS-BAS
U.E.B.L.
ITALIE
ESP.
IRLANDE
FINLANDE
YOUGOSLAVIE
PORT.
DANEMARK
NORVEGE
AUTRICHE
SUISSE
SUEDE
COMMUNAUTE ECONOMIQUE EUROPEENNE
ASSOCIATION EUROPEENNE DE LIBRE ECHANGE
AUTRES PAYS D'EUROPE
BASSIN MEDITERRANEEN
AFRIQUE
AMERIQUE SUD
EUROPE (C.E.E.)
AMERIQUE NORD, CENTR.
OCEANIE DIVERS
PROVENANCES DES IMPORTATIONS vers C.E.E.
B. MEDIT.
AFRIQUE
AMER. SUD
DIVERS
AMER. N. C.
PROVENANCES DES IMPORTATIONS vers AUTRES PAYS
B. MEDIT.
AFRIQUE
AMER. SUD
AMER. N. C.
DIVERS
CEE ANT.
PROVENANCES DES IMPORTATIONS vers A.E.L.E.
oranges, mandarines, clémentines
citrons
pomelos
E. TROCELLIER . I.F.A.C.

Introductory marketing of exotic fruits in the Federal Republic of Germany

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Summary

The structure of the German market, along with its dependence on imports particularly from other EEC countries and the fierce competitive nature of the retail food trade, including various types of retail outlet, give a background to the market for exotic fruits. German market must be in keeping with the high consumption of traditional fresh fruit along with the increasing standard of living and with due regard for the psychology of the German consumer with regard to foodstuffs.

The present situation is discussed in connection with motivations of the trade leading to the development of exotic fruit imports, source and type of fruit, transport, packaging and quality. The fruits considered include mangos, papaya, limes, chinese gooseberries, pineapples, passion fruit, custard apples, lychees and physalis.

Attention in the future should be drawn towards the production of top-quality fruit in a luxury pack, organization of exporting countries, and examination of potential supplies. The inflexibility of the IATA commodity rates structure should be considered.

Emphasis may be laid on the potential of out of season primeur vegetables in the German market.

Background Information

The Federal Republic of Germany is a country with some 60 million inhabitants. Some 1 million foreign workers are temporarily resident in the country – mainly from southern European countries, Spain, Italy, Turkey and Greece. These workers bring a breath of exoticism into Germany but it must be stated that the purchasing power of this section of the population is relatively low. The basic temperament of the population is conservative. I mention this to give you an idea of the type of consumer we are confronted with. The cosmopolitanism of Holland, Belgium and England – all former colonial powers – is not to be found to the same extent in the Federal Republic of Germany.

Another peculiarity of the country is that there is a large degree of decentralization. There is not – as in England, France and most other European countries – a city which can be classed as the cultural and social nerve centre of the country. Munich is as important as Hamburg; Berlin as important as Frankfurt and so on. The main density of population is in the Rhine/Ruhr area but this region is industrial and has not the purchasing power *pro rata* of other regions. This is an important point; it is not sufficient therefore for my group to be based in a central market and distribute from there. We must have our branches in all primary and most secondary markets – a total of some 50 branches.

The standard of living in the Federal Republic of Germany is high, the economy is booming: indeed possibly overheating. It is to be hoped that this situation will continue. With the increasing standard of living the consumer is tending to become more demanding. In the food sector, the days of frankfurters and sauerkraut are receding: the consumer is relatively interested in new tastes and foods.

To recapitulate, we have in the Federal Republic of Germany a large, decentralized market with a conservative population, which is however gradually becoming more and more interested in new ideas and has the standard of living to indulge in these.

These assertions are reflected in the fresh fruit and vegetable market. Imports account for very nearly half of

the total consumption of fruit and vegetables and well over one half of fruit consumption, as shown in the following figures for 1967:—

Imports of bananas	594,000	tonnes
Imports of citrus fruits	912,000	"
Imports of other fruits	1,402,000	"
Total imports of fruit	2,908,000	"
Domestic production of fruit	2,535,000	"

The consumption of fresh fruit is therefore very high — well over the level of the United Kingdom. For example in the Federal Republic of Germany we consume per head per annum:

10	kilos of bananas
10	kilos of oranges
1.6	kilos of other citrus
18.7	kilos of dessert apples

The Federal Republic of Germany is, as we have seen, not in a position to produce anything like its requirements of fresh fruits and is the largest fruit importing country in the world. Geographically the country is situated in the middle of vast European production areas — Holland, Spain, France and Italy as well as COMECON countries.

Traditionally, the Federal Republic of Germany has since the 1950's been able to import from the most favourable sources. No colonial lands committed us to give preference to particular areas and pay high prices. The world was open and preference was given to the country able to supply the best quality at the most competitive price. The development of the Common Market to its present — I hope only temporary — protectionism has modified this liberal trading policy somewhat but, in essence, we still buy more or less where we like.

The price of fruit and vegetables is therefore relatively low in the Federal Republic of Germany although the full customs union of the Common Market has forced many customs tariffs — and therefore prices — up.

The liberalism of German economic policy is reflected in the retail trade. Here we have observed, in the past five years, radical changes and a fierce competitive situation. The traditional independent greengrocer — who has never had the importance in Germany which he still has today in Great Britain — is being hard pressed by the competition of chain stores, multiples, self-service stores, supermarkets, department stores and, most recently, out-of-town consumer markets.

The competition for the favours of the housewife is to be seen in two ways: the size and quality of the assortment — that is to say the image of the types of produce available — and the price structure. The latter provides the impulse for modern stores, self service, rationalised warehousing and handling facilities and pre-packing. The former feature — the image — is what interests us here today.

The Import of Exotic Fruit

We have seen, that the Federal Republic of Germany is a market with a high standard of living and a high consumption of fruits — mostly imported. The trend is today very much towards the more delicate fruits and vegetables: beans in preference to cabbage, grapes in preference to apples and so on.

A large proportion of my group's turnover is conducted with the 'progressive' retail trade where the competition is fiercest and the future brightest. It became obvious that such retailers were basically interested in widening the assortment in their fruit and vegetable departments; in offering the housewife new ideas and in improving their image for quality and service: two features on which the German housewife places more importance than on the price.

Our first step was to introduce a national brand mark for fruit and vegetables — '1 X 1' — at about the same time as the United Fruit Company launched their "Chiquita" banana brand. This provided the first impulse in the trade to offer fruits and vegetables on a brand label system supported by a guarantee of consistent quality and publicity.

Our slogan for '1 X 1' produce is 'Fruits from all parts of the world in guaranteed quality'. The success of this and the continued interest of progressive retailers in improving their assortment led us to consider the possibility of airfreighting exotic fruits and out-of-season primeur vegetables to the market.

This trade was virtually non-existent in the Federal Republic of Germany; we were planning the marketing in close cooperation with the retail trade; there were therefore many problems to be solved.

The cost of transporting by air freight is high; we could not anticipate a large luxury market which would pay inflated prices; it was therefore necessary to obtain supplies from the most favourable source. Our decision was made to look for the majority of regular supplies from Kenya — a country which had both the highland temperate climate necessary for producing vegetables and the coastal climate ideal for tropical fruits. In addition, Kenya is now an Associate Member of the Common Market and, I hope, will benefit from tariff freedom when the Treaty of Association is finally ratified. It is the nearest potential supplier geographically and one of the cheapest from a transport point of view. Production was already extant and most of the basic prerequisites were therefore at hand. In the autumn of last year we therefore commenced imports from Kenya and established a programme of the various articles which we could handle and the quantities.

It was important to bring as wide a variety of produce as possible in order to offer a service to our customers. Further we were distributing to all ten German airports as well as to our associates in Vienna. The administrative control therefore had to be fairly strict. In the event, after a first marketing season it is gratifying to be able to confirm that our feeling for the market was not incorrect. The packaging used — 5 kg cartons with our '1 X 1' brand — the information leaflets

which we supplied and public relations work carried out ensured that the consumer was made fully aware of this new and exciting development by the retailer, the press, radio and television.

It would be foolhardy to expect success overnight and I will not deny that there were very many problems to be solved at all stages. The main fact is however that we have the potential for a very large market for air-freight produce in the Federal Republic of Germany. Given a favourable situation I would see a market for several thousand tons of produce a year being available in the near future.

In view of the generally low prices on the fruit markets and the glut of fruit available during the summer months, we limited our import season to the period November-May. Our object was to sell at a price which would ensure a satisfactory return to the producer while not being so high as to limit our trade to the luxury market. Our aim in the future must be to reduce costings so as to ensure that the maximum expansion of consumption is reached.

Future Potential

There is still a great potential to be realized on the German market. The marketing must however be very sophisticated so it is essential that we cooperate with suppliers who are fully aware of the situation. I realise that it is difficult for a producer or exporter in a developing country to appreciate the demands, or even at times the apparent perversity of our market. All I can say is that these requirements exist and can be ignored only at our own risk. The streamlining of the supply must also be reflected in transport; I often feel that established carriers are not doing enough through their organization, the IATA, to encourage a larger trade.

The German market is ready to be developed in this trade and we are always on the search for greater efficiency and better quality and service. I feel that basically Kenya or a West African country is our best potential supplier. I am looking forward to the time when I can report a full success for our ambitious project.

Comments on Individual Fruit

Finally, I will comment on the various articles which we have handled or which we would be interested in discussing.

Primeur vegetables especially *Green Peppers* and *Aubergines* are out of season in the European winter and fetch high prices. A large green pepper is required – a popular variety is Californian Wonder. Oval aubergines are preferred to the round ones.

Beans – haricots verts – also fetch very high prices. *Courgettes* are little known in Germany, but I am confident that there is a good market to be developed for this excellent primeur vegetable.

The *Mango* is possibly the most exciting of the exotic fruits. Until we started imports it was unknown; the interest shown in and the prices paid for good varieties are encouraging. There is no distinct preference for variety although Ngowe, Boribo and Alphonse varieties have been successful.

Papayas (pawpaw) are also interesting although they tend to be too large for convenient sale. I have come across small fruit (approximately 500 g weight) in the Ivory Coast, but this seems to be exceptional.

Pineapple is a difficult fruit. The fresh market has declined for years – mainly as a result of the poor quality – from Brazil, which used to be the only supplier and forced the consumer to turn to the processed product. We are offering air freighted pines of exceptional quality from Kenya, but the price discourages a larger market.

Chinese gooseberries, or Kiwis, are an exception to our regular exotic programme as they come by sea from New Zealand in the summer months. There is a great future for this fruit.

Custard apples, chirimoyas, are another exception. These are imported from Spain. I feel that this fruit will catch on although I would prefer to handle it as part of a larger programme.

I am not impressed either with fresh or processed *Lychees.* We have only taken small sample shipments from South Africa and I fear that the trade will not develop further as the flavour is basically alien to the European palate.

To end with a note of dissent concerning avocados. Our experience has not shown an appreciation of this produce in the German market. Preparation necessitates expensive trimmings and it does not fit in with my idea of a convenience food. I will hope to be proved wrong as I know that production is increasing.

Trade in less common tropical fruit

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Summary

The trade in the less common tropical fruit needs a different approach from that required for fruits, such as bananas and citrus, in which a large established trade exists. Trade is largely confined to individual producers and salesmen, the latter usually working on a commission basis. In this trade, recommendations made by the salesmen and wholesaler to the producers can be of the greatest importance.

Individual fruits are considered, including major countries of origin, general information on the fruits, and magnitude of the trade in the UK.

Future development of the trade in these rarer fruits is discussed. With continued high quality, general education of the public taste, and efficiency of salesmen, and, most important, advertising, there is every likelihood of at least maintaining sales at present levels, and in the long run, improving them.

The fruits with which this paper deals are those which are less common, and therefore those which are not imported into this country in such quantities as are, for example, apples, pears and citrus generally. As has been pointed out in a previous paper, the marketing of these 'bulk' lines is being increasingly controlled by Boards set up by the producing countries, who distribute the fruit to panels of salesmen in the principal markets of the United Kingdom. The quantities involved in the case of the less common fruit, into which category come mangoes, Chinese gooseberries, lychees, papaya and others, are obviously insufficient to warrant the formation of Boards to deal with their distribution, and so the trade in these fruits is still largely confined to the producer and individual salesmen.

This trade is to a very great extent on a commission basis, that is to say the fruit is dispatched to the salesman, who realises the highest possible market price, and returns the proceeds to the producer, having first deducted his percentage and any costs involved. This system works very satisfactorily. A good salesman will advise the grower on the varieties or types of fruit which are likely to make high prices; he will recommend certain packs and weights, and will criticize constructively, and adversely if necessary, when the produce is received. A sensible producer will take heed of this advice, and can be guided by an experienced salesman to send fruit of such quality and so well presented that it will realise the highest price obtainable in the market. He can also be recommended to send larger or smaller quantities so as to take full advantage of the law of supply and demand.

Increased facilities for transporting fruit by air have made a vast difference to the arrivals of tropical and subtropical fruit in the last decade or so. However, air transport is still far more costly than transport by sea, and therefore growers who send by air must receive high prices for their produce if the transaction is to be profitable to them. This means that the fruit must be of a high quality and in good condition in order to appeal to the high-class restauranteur or hotelier, or one or two of the higher class West End stores, because it is these buyers more than the general public who are prepared to pay high prices. Therefore the fruit must be very carefully selected, with only perfect specimens included, it must be correctly packed in the sizes or weights which

the customer prefers, and well presented. A first-class article well packed and presented will almost invariably make more money than the identical article placed without care in the wrong sort of container.

Another factor which has perhaps had some influence on the increased demand for these uncommon tropical and subtropical fruits is the development of the travel industry, with 'package tours' within the financial reach of a large proportion of the population. People who have eaten these fruits on holiday in the country where they are grown are likely to be interested in them if they see them on sale in their home town. As already stated, prices must be fairly high, but if air freight costs are reduced in the future, then these fruits could be sold at prices which the ordinary housewife could afford, and the fruit would become, in time, almost as common as the grapefruit or banana.

So much for general considerations, and we will now turn to the different fruits which come into this category.

Chinese Gooseberries. *Actinidia chinensis.* L. These are mainly produced in New Zealand, but they are grown to a limited extent in South Africa. They have even been grown in England, particularly in Cornwall and Hampshire, but this was as a novelty and they were not a commercial proposition. They have a rough, brownish, hairy skin, but a very delicate flavour, in which one can detect both the ordinary English gooseberry and the melon. Chinese gooseberries grow on a vine and are very prolific. They are brought to England from New Zealand by sea, carried at a temperature of just over 32°F., and packed in single layer trays, in counts of 40, 45, 50 and 55. In New Zealand they are known as Kiwiberries; attempts have been made to use this name in England, but the fresh fruit trade is very conservative, and having popularized the fruit under the name of 'Chinese gooseberry' they are reluctant to make any change, although it is neither Chinese nor a gooseberry.

Mangoes. *Mangifera indica.* L. This superb fruit, often referred to in Indian mythology and even now used in many Eastern religious rites, was first imported into England on a commercial basis from Bombay in 1925. It has increased in popularity in recent years, but not to the same extent as have avocados, for example. The original variety was the Alphonse, which was quite popular. Other varieties produced in South Africa, such as the Sabre and the Kidney, were not so popular as they were stringy and had a slight flavour of turpentine. More modern varieties, such as the Zill and the Kent, can be treated as one would treat a peach, and the flesh can be removed quite cleanly from the stone, but in the early days mangoes were so difficult to eat that they were reputedly best partaken of in a bath! Another mango with a delightful flavour is Peach, but that too is inclined to be stringy and is by no means a freestone. Mangoes are on sale in this country practically all the year round, mainly coming nowadays from South Africa, India, Kenya and the West Indies. They are packed in single layer trays. Apart from their superb flavour and texture, mangoes are extremely rich in Vitamins C and A.

Lychees. *Nephelium litchi.* Camb. These are a most luscious fruit, mainly supplied by South Africa and India. The season is short and supplies are limited. Some are sent by air, but the bulk come by sea and usually travel very satisfactorily. They are packed in boxes containing 10 pounds net; some are packed on the stalk and others are loose.

Papaya (Pawpaw). *Carica papaya.* L. These arrive spasmodically in very limited quantities from South Africa, particularly from the Transvaal around Tzaneen, and from the West Indies, the Canary Islands, India and Kenya. The fruits vary in shape and size but generally resemble the melon. The skin is smooth and bright orange when ripe, and encloses a thick layer of yellow-orange pulp. Papaya are excellent for helping the digestive organs, and contain a high percentage of pectin, much of which is extracted and canned, and this is used largely by explorers to the North and South Poles, as it helps to prevent scurvy. It is said that if a raw steak is placed inside a papaya it will eventually dissolve, but I cannot vouch for this, never having tried it. When I first visited South Africa in 1925 it was almost a ritual to have papaya before a main meal, because in those days the meat was usually a very old ox which had trekked the veldt until it was worn out, and then it was served as steak, and the papain contained in papaya helped to digest it. Papain can also be bought in this country dried and in powder form, in which form it is much used as a meat tenderizer. The fresh fruit does not travel satisfactorily by sea in cold storage, and therefore it is almost invariably sent by air.

Passion Fruit, *Passiflora edulis* Sims, is imported spasmodically almost all the year round. It is a native of Brazil, but it has been imported for many years from Madeira, the Canaries, South Africa, Kenya and New Zealand. It is popular in small quantities, and is used largely to add to a fruit salad. The juice makes a most delightful drink. In Madeira, ice cream with passion fruit flavour is very popular, and a proposal was made some years ago to manufacture ice cream with this flavour in England, but nothing seems to have come of it. Passion fruit is usually packed in double layer trays, and is carried mainly by air. Unfortunately it is not a good traveller, and the skin is inclined to shrivel after a short period.

Monsteras, *Monstera deliciosa.* Liebman. Before the war we received very limited quantities from Madeira and the Canary Islands. They are cone-shaped, and have a pineapple-like odour. They are eaten raw, or mixed in fruit salad.

Unfortunately the pulp contains calcium oxalate, which causes an uncomfortable itching to the throat, and so the demand fell away and nowadays it is rarely seen.

Grenadillas, *Passiflora quadrangularis* L., are natives of tropical America. The large, oblong, green or greenish-yellow fruit is not unlike a water melon, and contains a mass of purplish sweet-acid edible pulp, mixed with flat seeds. In its unripe state the succulent shell may be boiled and used as a vegetable. There are spasmodic shipments from Madeira and the Canaries, but the demand is very slight.

Guavas, *Psidium guajava* L., are also natives of tropical America. They are imported occasionally from

Mediterranean countries, and are used for jam or tarts, but their main use is for making the well-known guava jelly.

Mangosteens. *Garcinia mangostana* L., were first imported from India around 1930. The mangosteen is famed as one of the most delicious fruits of the tropics, and is considered by some to partake of the flavour of the strawberry and the grape. It is the size of a small orange, a beautiful reddish-purple colour. The rind is tough and forms excellent protection for the soft, snow-white and delicate flesh, rendering it suitable for package and carriage over fair distances. Unfortunately, this toughness of the rind has a disadvantage, because it can still appear perfectly sound when the fruit inside has collapsed and is mouldy. This is what happened when the fruit was imported, and so, after a few years the import of mangosteens has virtually come to an end.

Custard Apples. *Annona squamosa* L. These originated in the West Indies and Central America, and are now commonly cultivated in India, China and the Philippines. They are found spasmodically in the low-lying interior plains of the tropical continents, especially where the climate is hot and fairly dry, but they have received little attention and have not gained universal popularity. These are tree fruits, greenish-yellow in colour, with sweet, slightly acid but rather insipid flesh. Small quantities have been imported, mainly from Madeira.

Tree Tomatoes. *Cyphomandra betacea* **Sendt.** Unlike the ordinary tomato, this grows, as its name suggests, on a small tree, and is a native of Peru. It was introduced to Ceylon in 1882. The egg-shaped and smooth-skinned fruits are produced in great bunches in hanging clusters towards the end of young shoots. The sub-acid succulent fruits are refreshing and agreeable when eaten raw, but their chief use is for stewing, and they may also be made into jam. Before the war we used to receive fairly regular but small consignments from Madeira in their season, but the outlet in this country is very limited. They grow prolifically in New Zealand and are very popular there, and we have received spasmodic shipments from that country, and from the Canaries.

Loquats, *Eriobotrya japonica.* Lindl. Commonly known as Japanese Medlars, these belong to the apple family. They are cultivated in the Mediterranean countries, and in fact most warm countries, being suited to medium elevations in the tropics. The small ovoid or pear-shaped, yellow fruits, which are of the size of crab-apples, have a sweetish acid flavour, and are used for stewing, etc. The quality of the fruit, however, varies considerably according to variety and cultivation. During the season there are ample supplies from Cyprus.

Kumquats. *Fortunella* spp. This is another fruit of which limited quantities are received, but the outlet is very small.

The more common citrus fruits have already been dealt with in an earlier paper. However, there are two which I think could legitimately be included in a list of the less common fruit; they are the **Ugli** fruit and the **Ortanique**. These are both hybrids.

It was some 45 years ago that Mr. Sharp, a member of a very influential family of fruit growers in Jamaica, first started to produce ugli fruit on a commercial basis. The origin of the ugli fruit is to a certain extent a mystery; it is certainly a cross between at least two members of the citrus family, but nobody has ever been able to discover exactly which two were involved. It may be a direct cross between two members like an orange and a grapefruit, or it might have some lemon or tangerine or both in it as well. Attempts to reproduce the flavour by combining varying amounts of juice from different types of citrus were abortive. Ugli fruit are carried by sea, and normally arrive in very good condition. Their juice content is excellent, their flavour delicious, and they are very popular with those who have tried them, but they are still much more of a rarity than an orange or a grapefruit.

The ortanique is, as its name suggests, a cross between an orange and a tangerine. Ortaniques arrive in this country during the early part of the year and are very popular, but they are not yet widely known.

These are most of the less common tropical fruits which have been or are being imported into this country. It is impossible to give statistics, which can really only be compiled when produce is channelled through one organization, as it is in the case for example of South African citrus, or New Zealand apples and pears.

Whether or not trade in these rarer fruits could be developed to any appreciable extent is difficult to say. Three factors have to be considered, the quality of the fruit produced, the efficiency and knowledge of the salesman, and the education of the general public in order to create a greater demand for the fruit. These three factors cannot really be considered separately. If the salesman is knowledgeable he will ensure, by patient criticism and regular reports to the grower, that only fruit of the right quality reaches the consumer. The grower who ignores the advice and criticism offered to him by a really good salesman who knows his trade and his market is almost certain to come to grief. On the other hand a small grower who takes note of and acts upon the advice he is given, will sometimes develop into a very large grower, and this of course is true of growers at home as well as those in tropical countries. As to educating the public to be interested in this exotic fruit, the obvious answer would be advertising, but here there is a difficulty. In the absence of large Boards or other associations, who is to pay for the advertisements? There is no need to stress that unless advertising is on a fairly large scale it is likely to be a waste of money. Since at present the quantities received in this country of most of the fruits I have mentioned are comparatively small, the profits made by each of the growers would certainly not warrant the expenditure of some hundreds or even, without exaggeration, thousands of pounds which would be needed if an advertising campaign was to be effective.

It seems that the only way to expand the trade in these less common tropical fruits is to seize every opportunity for publicity which offers, and to con-

tinue to ensure that they are received in a condition as near to perfection as possible, and no doubt in time some of them will then no longer qualify for the term 'less common tropical fruits'.

Transport maritime des fruits tropicaux

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Sommaire

Les fruits tropicaux doivent arriver au port de débarquement avec un état de maturité tel qu'il permet d'obtenir une bonne commercialisation dans le délai de 5 à 10 jours qui est nécessaire pour cette opération avec, s'il y a lieu, une maturation complémentaire (banane).

Ce résultat est obtenu en observant deux sortes de conditions: des conditions générales qui s'appliquent à tous les fruits et des conditions particulières qui se rapportent à chaque espèce de fruit transporté.

Le nombre de ces conditions est élevé et il parait essentiel, dans toute la mesure du possible, de déterminer leur importance relative pour utiliser au mieux les possibilités du transport maritime.

Les conditions générales concernent: la qualité du fruit au moment de la récolte, le degré de maturité, l'état sanitaire, l'intervalle entre la coupe et le chargement, la manutention et la technique du transport maritime (puissance frigorifique, coéfficient de brassage, système de ventilation, renouvellement d'air, humidité relative), la vitesse de refroidissement, les variations de température, l'arrimage. L'importance de la vitesse de refroidissement est souvent sous-estimée.

Les conditions particulières se rapportent aux critères spéciaux de qualité pour chaque espèce de fruit, aux variations saisonnières de qualité, au mode de fonctionnement, à la sensibilité aux chocs, aux frottages, aux meurtrissures, à la température critique, à la production d'éthylène, à la sensibilité a l'éthylène, au déclanchement de la maturation pendant le transport pour les fruits à phase climactérique, à l'influence des contrôles successifs.

L'importance des conditions à observer n'a pas toujours été estimée correctement, c'est pourquoi, il est nécessaire de procéder à une mise au point basée sur l'experience acquise par le transport maritime au cours des dernières années.

Le transport des fruits tropicaux par voie maritime est une opération complexe qui a pour but de livrer à la commercialisation du pays d'importation des fruits d'excellente qualité (degré de maturité, état sanitaire, présentation, qualités organoleptiques).

Caractères généraux des fruits tropicaux transportés par mer

Les fruits tropicaux qui sont transportés par voie maritime présentent des caractères communs qu'il est nécessaire d'indiquer:

Ils sont en survie depuis la récolte jusqu'au moment de la consommation et ils ont des échanges permanents avec le milieu ambiant pendant cette période (respiration, transpiration, action de certains composés gazeux).

Ils sont exposés à une température élevée (entre 25°C et 35°C) depuis la récolte, jusqu'au refroidissement dans les cales du navire transporteur, ce qui a pour effet de stimuler leur activité physiologique et de diminuer leur stabilité.

Les fruits qui se ramollissent en mûrissant n'ont plus, lorsqu'ils sont mûrs, une résistance mécanique suffisante pour supporter sans dommage les manutentions. Ils doivent être maintenus en phase préclimactérique pendant toute la durée du transport.

La durée maximum de conservation des fruits tropicaux les plus importants au point de vue de la commercialisation (bananes, ananas, avocats, mangues) est de l'ordre d'un mois et il en résulte qu'il faut éviter d'effectuer des comparaisons avec la conservation de longue durée de certains fruits de zones tempérées. L'action des facteurs qui influencent la conservation (la température, l'humidité relative, la composition de l'atmosphère environnante) peut être différente dans le cas d'une conservation de courte durée, de celle de ces mêmes facteurs pour une conservation de longue durée (3 mois à 6 mois).

Périodes du transport maritime

On peut admettre que le transport des fruits tropicaux commence au moment même de la récolte et qu'il ne se

termine qu'à la livraison au grossiste, ce qui permet de considérer trois périodes distinctes dans le transport:

Une première période qui commence à la récolte et qui se termine à l'entrée dans les cales du navire transporteur.

Une seconde période comprise entre le chargement et le déchargement du navire.

Une troisième période qui s'étend du déchargement du navire à la commercialisation.

Si la première période ne constitue pas, à proprement parler, une phase du transport maritime, son incidence sur les résultats du transport est trop importante pour qu'il soit possible de l'ignorer.

Quant à la troisième période, elle ne constitue en fait que la continuation de la seconde.

Première période du transport des fruits tropicaux: à partir de la récolte jusqu'à l'entrée dans les cales du navire

Qualité de transport des fruits tropicaux

Les fruits doivent pouvoir être commercialisés en fin de transport avec l'état de maturité qui est demandé par le vendeur, sans présenter des altérations physiologiques ou fongiques.

L'ensemble de ces conditions permet de définir la qualité de transport de chaque variété de fruit au moyen de critères dimensionnels ou physiologiques. La qualité de transport n'est pas nécessairement identique à la qualité commerciale (elle n'a pas à considérer le calibrage, les normes de conditionnement et d'emballage par exemple). Elle fait appel à la notion essentielle de la stabilité du fruit pendant le transport: soit que le fruit doit rester en phase préclimactérique, soit qu'il ne doit pas arriver avec une maturité trop avancée. Elle considère la résistance des fruits aux altérations physiologiques et fongiques.

Stabilité des fruits tropicaux en phase préclimactérique

Le degré de maturité d'un fruit qui doit rester en phase préclimactérique pendant toute la durée du transport peut être défini avec deux catégories de critères différents: Des critères dimensionnels qui sont, en général, simples à mesurer, et des critères d'évolution physiologique dont la mesure est plus complexe.

Comme il y a souvent une bonne concordance entre les critères dimensionnels et les critères d'évolution physiologique, il est possible de se baser sur le développement des fruits pour fixer le moment de la récolte, mais si cette concordance n'existe pas, l'appréciation du degré de maturité doit s'effectuer en utilisant des critères d'évolution physiologique (aspect, dureté et couleur de la pulpe, odeur, etc.).

La stabilité des fruits tropicaux à la récolte pour un même degré de développement dépend de nombreux facteurs (climat, sol, fumure, état sanitaire de la plante—cercosporiose des bananiers, maladies des racines, etc.).

Il est donc indispensable de bien déterminer la valeur de ces critères, en fonction des conditions du transport (durée, efficacité du refroidissement, durée de la commercialisation, etc.).

Maladies physiologiques: les fruits tropicaux doivent être exempts de maladies physiologiques susceptibles de se développer en fin de transport (ex.: brunissement interne des ananas à certaines périodes de l'année).

Traitement antifongique

La séparation du fruit de la plante à la récolte se fait, le plus souvent, en sectionnant l'élément de liaison. La surface de la section de séparation constitue une blessure démunie de protection naturelle. Elle doit être traitée dans le plus bref délai, après la récolte, avec un produit antifongique efficace (par ex.: le Thiabendazol pour les bananes, l'acide borique pour les ananas, l'orthophénylphénate pour les agrumes), pour ralentir le développement de la flore fongique. Il est essentiel de souligner que le traitement antifongique ne sera efficace qu'à la condition formelle d'observer strictement les prescriptions qui sont indiquées en ce qui concerne la concentration du produit, la durée de trempage, le rinçage, etc. Il est fréquent de constater que des traitements antifongiques sont inopérants parce que les conditions d'application sont défectueuses.

La déshydratation des cellules de la surface de séparation de la plante favorise le développement des pourritures. Daudin, Deullin et Heut, (1955) ont montré que la déshydratation constitue un des facteurs dominants de l'altération des hampes des régimes de bananes.

Cette importante question du traitement antifongique est étudiée par MM. Brun et Laville, pour le cas de la banane, dans le mémoire 'Contaminations fongiques des Bananes durant et après la récolte' qui est présenté à cette conférence.

Lorsqu'il n'est pas possible d'effectuer le traitement antifongique dans un court délai après la récolte, il peut être utile de sectionner une portion de hampe ou de pédoncule pour pouvoir l'effectuer sur une surface qui n'est pas encore contaminée.

Durée de l'intervalle coupe-chargement

Entre la récolte et le chargement dans le navire, les fruits tropicaux sont exposés à une température ambiante comprise entre 25°C et 35°C, dont la valeur moyenne dépasse la température du transport maritime d'une vingtaine de degrés environ, il en résulte que l'intensité respiratoire des fruits, qui constitue un critère d'activité physiologique, est cinq fois plus élevée que celle des mêmes fruits lorsqu'ils sont refroidis. Cette activité physiologique intense s'effectue au détriment de leur stabilité et c'est ce qui explique que la durée de l'intervalle qui s'écoule entre la coupe et le chargement dans une enceinte refrigérée doit être aussi courte que possible, particulièrement pour les bananes, les ananas, les avocats.

La très grande importance de ce facteur a été démontrée expérimentalement dans le cas des bananes, avec le

remplacement des housses en polyéthylène par des caisses en carton qui conduisent mal la chaleur et qui sont plus difficiles à refroidir que les housses en polyéthylène. La pratique du transport a montré que les avaries avaient diminué avec l'emploi des caisses en carton, parce que l'utilisation d'ateliers de conditionnement qui simplifie le travail du producteur a permis d'obtenir un intervalle coupe-chargement d'une durée inférieure à 24 heures, alors que précédemment, cet intervalle était fréquemment double ou triple.

Conditionnement

Le conditionnement consiste à placer les fruits dans l'emballage qui est utilisé pour le transport, après avoir effectué les traitements prévus (lavage, triage, traitement antifongique, etc.). Cette opération présente une grande importance, parce qu'elle permet de procéder à un contrôle de la qualité de transport et d'assurer la protection des fruits contre les chocs normaux de la manutention (chargement et déchargement de camions, entre la station de conditionnement et le port, chargement et déchargement du navire, chargement et déchargement du camion entre le navire et le grossiste).

L'ananas, qui est particulièrement sensible aux chocs, doit faire l'objet d'une attention toute particulière pour les manutentions et l'emballage.

Le transport entre la plantation et le quai de chargement

Ce transport doit être effectué rapidement et sans occasionner de blessures ni de meurtrissures. Les altérations produites par le transport et les manutentions après le conditionnement n'auront pas de traitement antifongique et des pourritures pourront se développer pendant toute la durée du transport maritime et de la commercialisation.

Seconde période du transport des fruits tropicaux: le transport maritime

Température critique des fruits tropicaux et température de transport

Il y a une température critique au dessous de laquelle les fruits tropicaux sont altérés:

Bananes: etre 11 et 14°C suivant la variété (Furlong, 1956) (Wardlaw et McGuire, 1931).

Avocats: entre 5°C et 12°C suivant les variétés.

Ananas: au dessus de 7°C (Py, et Tissean 1965).

Mangues vertes: à 10°C.

La température de transport de chaque variété de fruit se détermine en ajoutant à la température critique une marge de sécurité de 0·5°C à 1°C, pour tenir compte des fluctuations de fonctionnement de l'installation frigorifique du navire. Cette température se contrôle au point le plus froid de la cale du navire.

Caractéristiques techniques du navire de transport

Actuellement, les charactéristiques techniques du navire de transport sont bien connues:

Coefficient de brassage de 80 à 100 pour chaque tranche de ventilation.

Taux de renouvellement d'air frais: 1 à 2 par heure.

Système de ventilation verticale en série (ascendant ou descendant) (le système de ventilation latérale est abandonné).

Puissance frigorifique: 150 à 250 frigories/heure par m^3 de cale. Installation frigorifique décentralisée, à détente directe au R 12 ou au R 22.

Régulation automatique de la température de l'air avec une précision de ± 0·2°C.

Fonctionnement automatique des compresseurs frigorifiques, qui peuvent être du type semi-hermétique ou verticaux multicylindriques avec réduction de puissance.

Les batteries de frigorifères sont constituées avec des tubes à ailettes en acier galvanisé. Elles ont une grande surface pour obtenir une humidité relative élevée de l'air de ventilation (85 à 90%).

Le taux de renouvellement d'air frais en continu de 2 à l'heure parait excessif, c'est une valeur établie empiriquement. En matière de renouvellement d'air, l'essentiel est d'assurer un balayage complet et continu des emballages de la cargaison par l'air en circulation, ce qui revient à dire que le renouvellement d'air ne sera valable qu'avec un système de ventilation efficace. Le taux de renouvellement d'air frais pourrait être abaissé à la fois par heure avec un système de ventilation bien conçu.

Arrimage des emballages

L'arrimage des emballages a une grande importance sur le refroidissement. Il doit être régulier pour ne pas occasionner des cheminées qui constituent des passages sans résistance qui seront utilisés de préférence par l'air. Lorsqu'un compartiment est incomplètement chargé, il faut diminuer la hauteur de chargement pour couvrir toute la surface du plancher soufflant. Une autre méthode consiste à obturer la surface du plancher qui n'a pas reçu d'emballages, pour empêcher le passage de l'air dans les parties libres du plancher.

Refroidissement des fruits en emballage carton

Le refroidissement présente une grande importance dans le cas des fruits tropicaux parce qu'il ralentit leur activité physiologique, parce qu'il diminue la perte de poids par déshydratation et parce qu'il ralentit le développement des altérations fongiques. Il doit être effectué le plus rapidement possible en utilisant le maximum de moyens.

Son importance est liée à l'activité physiologique du fruit qui est transporté; elle est capitale pour les bananes, les ananas, les avocats qui ont une activité respiratoire élevée et elle est souvent sous-estimée. L'utilisation des emballages en caisses carton ne facilite pas le refroidissement parce qu'ils sont constitués par du carton ondulé

qui est composé de deux couches de papier kraft, séparées par une onde qui constitue une lame d'air. Le coefficient de conductibilité d'une double épaisseur de carton ondulé est de l'ordre de 2 à 3. Dans le cas de l'arrimage compact qui est utilisé habituellement, l'air de refroidissement ne peut balayer qu'une partie des parois latérales des emballages. Une expérimentation a montré que cette surface est comprise entre 70% et 80% en moyenne de la surface des parois latérales d'un emballage, Ainsi, dans le cas d'un carton de 64cm × 39cm × 22cm avec une surface totale de 0·97 m^2, la surface utile de refroidissement n'est que de 0·30 m^2 environ parce que l'air de refroidissement ne circule pas entre les fonds et les dessus des emballages. A titre d'exemple, la vitesse de refroidissement des bananes dépend du mode de conditionnement et de la position dans l'arrimage.

Pour des régimes de bananes en housses de polyéthylène, la vitesse de refroidissement horaire moyenne pendant les cinq premières heures était de 1·2°C/heure (Navire Tarpon—1960).

Pour des bananes en caisses en carton, sans perforation, la vitesse moyenne de refroidissement horaire pendant les cinq premières heures était de 0·7°C/heure.

Pour des bananes en caisses en carton, avec des perforations sur les parois latérales, la vitesse de refroidissement horaire moyenne pendant les cinq premières heures était de 1·2°C/heure. La vitesse de refroidissement doit être aussi grande que possible, et il n'a pas été démontré qu'un refroidissement rapide était nuisible.

La courbe de refroidissement n'a pas une forme linéaire au début du refroidissement et il est important d'obtenir rapidement la température de stabilisation, ensuite, la seconde phase du refroidissement pourra être plus longue sans qu'il en résulte un inconvénient notable.

Période du transport aprés le refroidissement des fruits

Les fruits doivent être maintenus à la température de transport jusqu'au déchargement du navire; c'est la période de transport à température constante. Une discussion a eu lieu dans le but de déterminer l'importance relative de la période de refroidissement par rapport à celle du transport. Il n'est pas possible de répondre avec précision à cette question, parce qu'il n'y a pas eu d'essais systématiques à ce sujet et parce qu'il faut faire intervenir la durée du transport.

Personnellement, nous considérons qu'en matière de transport, la rapidité du refroidissement constitue un élément primordial. Lorsque les fruits ont été refroidis rapidement, il ne parait pas nécessaire de maintenir la température de transport avec une précision rigoureuse du dixième de degré Celsius. Des légères fluctuations de température dans un intervalle de 0·5°C ne paraissent pas avoir des conséquences notables. Il semble que l'importance de ce facteur a été exagérée et il ne semble pas justifié d'imposer le maintien de cette température au 1/10e de degré C près.

L'éthylène joue le rôle d'un déclencheur de maturation. Fidler (1961) indique que son action ne se fait pratiquement pas sentir à 3°C, qu'un effet modéré se manifeste à 7°C, alors qu'à 12°C l'effet stimulant de l'intensité respiratoire est marquée. Gane et Robinson (1962) a montré que la production d'éthyléne augmente brusquement, 24 heures environ avant celle de l'intensité respiratoire. L'éthyléne doit être éliminé de l'air en circulation fermè dans les cales du navire transporteur, au moyen du renouvellement d'air frais, ce qui ne présente pas de difficultés. Il a été considéré que les gaz d'échappement des moteurs des navires pouvaient constituer une source d'éthylène. Pour éviter leur action, il est recommandé de maintenir les cales en légère surpression, avec une admission d'air frais supérieure à la sortie de l'air vicié.

Il est important de maintenir une humidité relative élevée de l'air en circulation dans les cales. Pour une durée de transport limitée à deux à trois semaines, l'action d'une humidité relative élevée aux températures utilisées pour le transport des fruits tropicaux est bénéfique. Elle limite la déshydratation des cellules à la surface des blessures qui sont moins vulnérables aux infections fongiques et elle diminue la perte de poids.

Incidents en cours de transport

Maturations isolées

Il y a encore quelques années, il était considéré que les fruits qui entraient en maturation provoquaient la maturation des fruits avoisinants, ce qui a constitué la théorie de la maturation par contagion.

Présentement, avec des cales de navires équipées avec un système de ventilation et de renouvellement d'air frais efficace, la chaleur et l'éthylène produits par des fruits entrant en maturation sont éliminés sans difficulté et les fruits entrés en maturation n'agissent pas directement sur les fruits placés dans des emballages voisins.

En outre, la maturation qui se déclenche lorsque les fruits sont déjà refroidis à la température de transport se produit au ralenti.

Arrêts de la ventilation

Les arrêts de la ventilation, lorsqu'ils sont de courte durée et lorsqu'ils se produisent après le refroidissement de la cargaison, bien qu'ils ne soient pas recommandables, n'ont pas d'effets importants sur le comportement des fruits en cours de transport et il est possible d'effectuer la réparation nécessaire (remplacement d'une roue de ventilateur ou d'un rotor de moteur électrique) sans dommage appréciable.

Ouvertures des cales en cours de transport

Les ouvertures de cales de durée limitée, en fin de transport, n'ont pas d'effets notables sur la cargaison, si la température des fruits ne varie pas sensiblement, en maintenant par exemple une ventilation réduite et la refrigération pendant la durée d'ouverture d'une cale de quelques heures.

Conditions particuliéres de transport des fruits tropicaux

Chaque variété de fruits tropicaux présente des caractères spécifiques qui se traduisent par la necessité d'observer des conditions particulières qui s'ajoutent aux conditions générales qui ont déjà été mentionnées.

Ces conditions particulières se rapportent à des critères de qualité, à la température de transport, à la sensibilité plus ou moins grande aux chocs de manutention, à la sensibilité à la déshydratation, à l'action de l'éthylène, etc. Nous nous bornerons à indiquer ici, à titre indicatif, quelques unes de ces conditions particulières pour quelques fruits.

Les bananes doivent être récoltées et transportées en phase préclimactérique. Le degré de maturité d'un fruit normal est défini par sa plénitude, mais il peut arriver que le degré de maturité de la pulpe soit plus avancé que ne l'indique la plénitude qui est seulement un critère dimensionnel; il faudra alors se baser sur des critères de qualité de transport qui s'appliquent à la pulpe de la banane (couleur, aspect, dureté, odeur, etc., en choisissant de préférence, le fruit représentatif du régime). La température critique de la banane est élevée (entre 11° et 14°C) et l'altération de ce fruit par le froid dépend de l'action conjuguée de la dureé et de la température.

Furlong (1956) donne les précisions suivantes:

Banane Gros Michel: pas d'altération par le froid au dessus de 53°F.

Banane Sinensis naine: pas d'altération par le froid au dessus de 52°F.

Banane Lacatan: pas d'altération par le froid au dessus de 58°F.

La peau de la banane est très sensible au frottage qui enlève la couche protectrice constituée par de la cutine.

Les meurtrissures de la pulpe produisent une augmentation momentanée de l'intensité respiratoire et peuvent réduire la durée de la phase préclimactérique.

L'éthylène favorise le déclenchement de la phase climactérique, avec une production d'éthylène par la banane qui est 50 fois plus grande environ (0·0004mg./kg./24 heures en phase préclimactérique contre 0·02mg./kg./24 h un peu avant le maximum de la pointe climactérique (Gane, 1962).

La maturation de la banane déjà refroidie s'effectue lentement, sans gêner le transport d'un lot complet.

La déshydratation des surfaces de séparation et des surfaces des blessures favorise la nécrose des cellules et la pénétration des infections fongiques. Les pliures de pédoncules provoquent des blessures internes avec développement ultérieur de pourritures. Chaque année, pour chaque territoire de production, il y a une période défavorable pendant laquelle la peau des bananes est particulièrement sensible aux altérations fongiques.

Les ananas sont très sensibles aux chocs qui provoquent des meurtrissures qui occasionnent des pourritures. Ils doivent être manipulés avec un soin tout particulier, depuis la récolte jusqu'à l'introduction dans les emballages qui doivent être étudiés spécialement pour assurer une bonne protection pendant les manutentions.

La maturité apparente de l'annas (couleur) est souvent différente de la maturité réelle qui se juge par la couleur et l'aspect de la pulpe dans la plus large section du fruit. La couronne se fane lorsqu'elle est placée en atmosphère sèche. Le pédoncule de l'ananas doit être traité contre la pourriture.

Les avocats doivent être transportés en phase pré-climactérique. L'évaluation du degré de maturité est délicate. La durée l'intervalle coupe-chargement ne doit pas dépasser 24 heures. L'utilisation d'emballages perforés est recommandée pour faciliter le refroidissement.

La température de transport dépend de la variété. Elle est de l'ordre de 5°C à 7°C pour les variétés mexicaines ou guatémaltèques et elle est comprise entre 10°C et 12°C pour les variétés antillaises.

Les sections des pédoncules doivent être traitées pour éviter la formation de pourriture à la base du pédoncule au moment de la maturation.

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The future in overseas transport of fruit

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Summary

Overseas transport of fruit is in a period of flux mostly on account of changes in packaging; on the small scale with the change from wooden boxes to cartons and on the grand scale with the freight container. The carton has influenced many trades and none more than the banana trade. The freight container has still to make its impact but there can be no doubt that it will.

The advantages together with the disadvantages and limitations of the freight container are discussed, and reference made to problems in applying refrigeration to containers. The application of controlled atmosphere storage to containers and sea transport generally is discussed. The combination of controlled atmosphere storage and the rapid transit possible with a container ship may well prove a possible alternative to air transport for the more exotic and tender fruits and vegetables.

The paper goes on to refer to the ever present problems of ocean transport of fruit which are unaffected by the method of carriage. In many cases the problems exist only by virtue of the difficulties of applying existing knowledge. These reasons are often economic but sometimes seem to be incomplete appreciation of the significance of existing knowledge.

There are four basic parameters with which anyone concerned with transport of fruit and vegetables must concern himself. These are, the quality of the produce offered, time, temperature, and atmosphere. The first of these is beyond the control of the carrier except that he may refuse to carry the produce if its condition is not to his liking. Leaving aside the characteristics of individual fruit, the most important factor common to all tropical and subtropical fruit is that it is likely to be harvested at a high temperature. As tropical areas tend to be some distance from their export markets it is generally important to get the maximum storage life from the fruit. In order to achieve this it is essential to reduce the temperature of the fruit in the shortest possible time. In situations where pre-cooling is not possible, it is then necessary to control the harvesting of the fruit in terms of maturity and of time relative to its delivery into the transport system. A case in point is the banana, which is cut to a degree of fullness appropriate to its journey and within a maximum number of hours of its being loaded into the ship.

There are exceptions to this control of pre-shipment conditions and where there are the trade is usually characterized by a percentage of failures. Whether the saving in not having adequate pre-shipment control of pre-cooling is ever worth failures and consequent poor reputation is worth careful consideration. The transport system can only make the best of what it is given and can only retard development, not stop it. For the most part, during transport, time and temperature are the only relevant variables. The time factor may be almost eliminated by air transport, and all that is necessary is to ensure that there are minimal delays at airports, etc., some measure of temperature control is necessary but it is not as important as temperature control during longer journeys. This paper will not deal with air transport.

Where transport by ship is concerned time is often a limiting factor and strict control of temperature is necessary. Nevertheless, there is no point in adding unnecessarily to the cost by oversophisticated transport. All forms of transport of fruit in quantity on board ship require a constant circulation of air in order [illegible]

being removed by air exchange, hence ambient temperatures are critical. This is the cheapest method of carrying fruit but has obvious limitations. One stage removed from this is when the carrying vessel is uninsulated or only lightly insulated but the air in the cargo spaces is mostly recirculated and cooled by refrigeration. This is particularly interesting for the more durable fruits moving from the subtropics directly into cooler water. The most important method of transport is, however, in cargo spaces which are both insulated and refrigerated. Fruit should not, in general, be carried in cargo spaces which are insulated but not refrigerated. Such spaces have been used for the transport of subtropical fruit for a voyage through the tropics but circumstances have to be favourable and the need is great for this method to be considered. (Cooper and Bester 1959) Insulation by definition retains heat and fruit in insulated spaces may well rise in temperature to a disastrous extent if not refrigerated.

This need to have a vigorous air movement through the cargo means that the cargo space in the ship or the container must be provided with means for circulating this air and means for distributing it through the cargo. This is not enough; the cargo must be so packed and stowed that it is possible to get an even air flow through it. The design of the package is important and has become increasingly so with a change from wooden to fibreboard cases. By and large the wooden package presented no problems in arranging for an even flow of air through the load. Cases had bulges, cleats, and inevitable slight misalignments in the stow meant that there were many channels for air movement. Provided that there was no opportunity for air to by-pass the cargoes through large gaps in the stow it is possible to get reasonably uniform air flow. Cartons, however, have somewhat different characteristics and although similar crevices will be left in the stow when the cartons are placed in position the carton moves under the load and tends to fill these crevices. This means that with cartons, if one wishes to be absolutely certain that there is air movement over a surface, wooden spacers or dunnage must be used. Not everyone does this and much fruit has been carried successfully in cartons which have not been deliberately spaced. Nevertheless, there is a record of failure by over heating and those who wish to avoid any risk use separations. This is, however, a tiresome and expensive way of stowing cargo and the future lies with a package which will form a satisfactory stow without separating dunnage. There have been several attempts to design a self-dunnaging carton but so far none have been entirely successful. An alternative is the ventilated carton which allows air to move through the package; this assumes that air can move freely within.

A form of pack which has been of considerable use with deciduous fruit and which now has begun to be used for citrus is the bulk bin. This in essence is a square chest holding about 1,000 lb (454 kg) of fruit. In the most highly developed form the fruit is selectively packed straight into the bin and all grading is done after arrival in the importing country.

Marine transport is now in the throes of a revolution which could have a profound effect on fruit transport. This goes under the general title of containerization. The container sometimes referred to as the freight container is in effect a large box which may be anything from 10 ft. (3m) to 40 ft. (12m) long and usually but not invariably 8 ft. (2.5m) by 8 ft. (2.5m) in section. The bulk bin of the previous paragraph is more than half way to the smaller type of fruit container. These are neither insulated or refrigerated and are carried in the refrigerated holds of a conventional ship. As such they are more a development of packaging than of what is now accepted as a container. The freight container has existed for some considerable time and has been carried on conventional ships usually on deck and very occasionally below decks. In its refrigerated form there is a built in refrigeration unit driven off the ship's power or by an internal combustion engine; sometimes there are alternative sources of power. Used in this way a container is no more than a convenient and expensive way of adding to the refrigerated cargo space on a ship. It is justified where there is incentive to carry refrigerated cargoes on ships which when built were not so equipped. The real advantage of containers came with the container ship developed notably by Matson (Harlander, 1960) and Sea-Land companies of the USA. These ships carry nothing or almost nothing but containers. These are loaded and discharged in a very short time. These ships offer the opportunity of a door-to-door service often without the intermediate handling of the goods and in a shorter time than was hitherto possible.

Carriage of refrigerated containers in container ships has its problems and the best answer will depend on circumstances. In the first container ships the refrigerated containers were of the type described in the previous paragraph and were carried on deck. This, however, limits the number that can be carried and the Matson Line converted one ship so that this type of container could be carried below deck. The problem then is removal of the heat dissipated by the refrigeration unit; this amounts to the total power supplied. For land operation it is essential that the refrigeration unit should have an air cooled condenser. In a ship's hold this would be quite intolerable except perhaps for the single container. The solution adopted by Matson was to have a dual condenser, air cooled for overland and on-deck operation with a water cooled alternative when operated below decks on board ships (Harlander, 1961). An alternative method of carrying containers below deck is to have a central refrigeration system on board ship. This supplies refrigeration to a number of air coolers and each air cooler supplies cold air in closed circuit to a number of containers. The choice of system depends on the circumstances. If the amount of refrigerated cargo is such that all the containers can be carried on deck then the container with self contained refrigeration system and air cooled condenser is the simplest. It has the merit that the refrigeration system and its prime mover are equally usable wherever the container may be. If more containers have to be carried than can be accommodated on deck a choice has to be made between one of the other two systems.

If each container has its own refrigerating machine it is still relatively simple to refrigerate from door to door, although as electric drive is essential below decks, either electric power has to be available from the road vehicle or dual electric/internal combustion engine drive has to

be supplied on the container. The disadvantages of this system, as against one with a central plant on board ship, increase with the number of containers to be carried. There will come a point where a central plant is definitely cheaper and as the number of containers increase there will also come a point where the risk of a breakdown of a unit during the voyage moves from being a statistical risk into becoming a certainty. The statistics of breakdowns in such units are probably insufficiently well known for strictly logical thought on this point. Eventually a specialized maintenance staff will have to be carried: the longer the voyage the more important will it be to deal promptly with breakdowns on board. The system of cooling containers from a central plant is relatively new in application but works well. It has one very considerable advantage for transport of fruits and vegetables in that if the cells are insulated the air around the containers will be cool and if necessary can be controlled in temperature. This point will be discussed later. The main disadvantage is that when not on the ship the container is an insulated but unrefrigerated box. If the container is loaded for any length of time before delivery to or removal from the ship's system, refrigeration may have to be applied to it. If this holding period is in port and the number of containers large enough, then a special storage stack with a refrigeration system similar to that on the ship can be provided. Otherwise a refrigeration unit of the type known as a 'clip-on unit' has to be attached to the container. The disadvantage of this in terms of maintenance and handling will be obvious.

In brief, if the number of containers to be carried is large, the voyage long, and the movement on land away from the ports limited, a system with central refrigeration on board ship is the clear choice. When the number of containers is small and the voyage is short in relation to the land operation, then individually refrigerated containers are more likely to be the best solution. For any particular operation the balance of advantages and disadvantages must be drawn with some care before a decision is made. Experience is still far too limited for any general assessment, if indeed this will ever be possible.

It is then necessary to consider just what the container will or will not do in relation to whatever fruit is carried. In general, the smaller the refrigerated space the bigger will be the spread of temperature within it. This is because of the greater surface for heat leakage in relation to the cargo volume. The air removing the heat leak must rise in temperature proportionally to the magnitude of the leakage. This temperature rise will inevitably tend to be higher in smaller spaces and a container is a very small space. To a certain extent this tendency can be compensated by extra insulation on the container but this reduces cargo carrying capacity which is already at a premium. The effect of heat leak on the load can also be reduced by what is generally referred to as the jacket system (Lentz *et al* 1961; 1966). In this the heat leaking through the insulation is removed by air that has already passed through the cargo. The rise in temperature of the air in passing through the container is not therefore, fully reflected by a corresponding spread of temperature in the cargo. The effect of small size can also be compensated by a higher rate of air circulation, this however puts up fan power and in consequence refrigeration power costs. There is a limit to what can be done by any of these methods and it falls short of full compensation. The spread of temperature in a container can, therefore, be wider than in conventional marine transport. An exception to this is the container ship with central plant and insulated cells. By controlling the temperature of the air in the cells so that it is approximately the same as the carrying temperature of the fruit in the container, heat leakage can be practically eliminated. Carrying conditions then are very much better than in conventional ships and are near to the best possible. Containers at the ambient temperature normally reckon to compensate for somewhat poorer temperature conditions by a speedier door to door transit and less handling with less mechanical damage.

Something must be said about the control of the small refrigeration units used on containers. (Scrine, 1969) It is only very recently that thought has been given by the manufacturers, to the various problems of carrying fruit. Hitherto they have been designed for the carriage of frozen foods. The unit will, therefore, hold the container at -20°C or lower in an ambient temperature of 34°C or so and run for perhaps 18 out of 24 hours in doing so. When carrying fruit the refrigeration output of such a machine at the higher evaporating temperature will be perhaps increased fourfold. It will only operate, therefore, for four of the twenty four hours. This proportion of running time is very difficult to manage and is only made tolerable by allowing the temperature to rise and fall through a fair range of temperature. A second and associated problem is the method of control. The circulating fan must run continuously when fruit is being carried. In most containers the temperature controlled is that of the air as it leaves the container on its way to being re-cooled. If for example, this control is set at 3°C the temperature of the air entering the container will be substantially lower, possibly below freezing. It is advisable, therefore, to put a limit control on the temperature of the delivery air so that this cannot fall below the freezing point of the fruit. There is then another problem of control in ensuring that the unit does not hunt. When the refrigeration cuts out as the temperature of the delivery air falls below the preset value the sensing element is immediately washed by air coming straight off the container, the temperature, therefore, rises rapidly and the unit will start again. This could lead to very short cycles of refrigeration and it is necessary to add to any inbuilt delays in order to prevent this. The ideal method of control would be to be able to keep the unit running continuously by adjustment of its output so that it exactly balanced requirement. Some measure of capacity control is being introduced into these units in order to improve their versatility.

Experience with stowage of packed fruit in containers is limited but what there is does suggest that this is not a very critical feature. Certainly whenever temperatures have been measured in container loads of fruit the tighter stows have been every bit as good as the more open ones. Pallets can be carried perfectly well in containers and if pallet transport were to become universal economies could be made in container construction. Most refrigerated containers have a floor designed so

that air will flow beneath the load. Pallets could ensure this, making unnecessary this rather expensive floor. Pallets would also be the answer to a handling problem with containers. Fruit can arrive almost at its final destination with no mechanical damage but in the unloading of a container enough damage can be done to nullify any earlier benefit.

Finally, there has been some experiment with controlled atmosphere storage in container transport. The problems of what can or cannot be done by CA conditons during transport are problems of the individual commodities and beyond the range of this paper. It is not easy to make a container sufficiently gas tight and unless it is, it will be difficult to hold the required conditions or expensive to maintain them, particularly if the displacement of nitrogen from a liquid nitrogen tank is the method used. It is too early to guess what future this method of transport in containers will have but it would appear to offer some hope as an alternative to air transport as a means of exporting some tropical fruits and vegetables. Much work will be needed before this hope can be given any solid foundation.

In conclusion, it is necessary to retain a sense of proportion about containers and with the immense publicity they are currently receiving this is not easy. Containers by themselves solve no problems except to be a convenient way of providing a small amount of additional space. This may be particularly useful when the amount of cargo moving is small and no other suitable means of carrying it are available and container lots can be very useful when developing a new trade. It is necessary to remember the vulnerability of the isolated container. Where possible, when stationary for any length of time on land or on deck a container should be protected from direct sunlight. If they are being used for carrying fruits of limited life or for trial shipments the containers should receive priority in handling.

Containers in a container ship are an entirely different proposition. Speed of handling can be taken for granted but even here delays may occur on land. It is probably a reasonable rule for fruit of limited life, as are most tropical fruits, to allow for a transit time no longer than half the total storage at the temperature of carriage. Here again the refrigerated containers when carried on deck should be protected by never being placed on the top most or outmost layer of containers. A container ship service nevertheless can offer a new opportunity for exporting the more short lived fruits. It is likely, however, to be some time before container ship services are universally available; they are still relatively in their infancy and are only likely to operate where there is a considerable volume of trade.

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Problems in long-range transport of fresh avocados, mangoes, and pineapples

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Summary

There appear to exist favourable possibilities for a large expansion of the world trade in fresh avocados, mangoes and pineapples provided that more reliable and at the same time sufficiently cheap methods of long-range transport may be developed.

The storage properties of avocados, mangoes and pineapples are described. These fruits have a relatively short storage life even under optimum conditions. They generally show considerable sensitivity to chilling injury and are highly liable to microbial storage diseases. The optimum holding temperature is usually in the range 5° to 10°C. For various reasons, these fruits cannot be transported in the same space together with the major fresh fruit commodities (bananas, apples, pears, grapes, citrus) except for very short periods of time.

The merits and demerits of intercontinental transport by air versus by sea are briefly analysed. The big advantage of air transport is the short time required, its main difficulty, high costs. Sea transport is much less expensive but often does not at the present stage of technical development, give full guarantees for perfect quality on arrival and sufficiently long residual storage life for successful marketing.

The problems involved in sea transport are reviewed in some detail. Possibilities for improvement of the present technique are discussed. It is indicated that the introduction of reefer containers may well create a major technical break-through for long-range maritime transport of the fruits under consideration.

It is stressed that conditions *before* transport are of paramount importance. A number of the factors involved are discussed – e.g. production conditions, disease control in the plantations, harvesting maturity, grading, packing and precooling.

Production, world trade and market potential

The world production of fruits exceeds 150 million tons a year. Avocados, mangoes and pineapples make up a relatively small part of this quantity.

Statistical data for the production of avocados are very incomplete. Available records indicate USA to be the largest commercial producer with a total yield of about 60,000 tons per year. Other producers of importance are South Africa (4,000 tons), Israel (2,000 tons) and a number of countries in Central and South America. No reliable figures for world production of mangoes are available. The main growing area, however, is India with an annual output of some 3.5 million tons. The world production of pineapples is around 3.5 million tons per annum. Of these about 41% are produced in Asia (Malaysia, Thailand, Formosa, India, Philippines, etc.), almost 27% in Hawaii, 11% in South America, (Brazil, Ecuador, Venezuela, etc.), 7.5% in Africa (South Africa, Ivory Coast, etc.) and 5.5% in the West Indies.

Only a relatively small part of the production enters international trade as fresh fruits. The total volume of this trade for all kinds of fruits is estimated to be around 15 million tons.

International trade in avocados is still very small, the annual volume probably being between 2,000 and 3,000 tons. No figures on international trade in mangoes are available but it is supposed to be still smaller than in avocados.

International trade in fresh pineapples has reached a much higher volume than in avocados or mangoes. It is estimated to be around 120,000 tons per year.

There are indications that the potential for increase of international trade in fresh avocados, mangoes and pineapples is very large indeed. Thus, imports of fresh pineapples to the EEC countries rose by about 70% between 1961 to 1966. According to a recent estimate (Anon. 1968) the potential market for avocados in Western Europe is 25 - 45,000 tons per year.

The fruits discussed here are presently judged as luxury items on the markets of most industrialized countries. It is strongly believed that a reduction in price would pave the way for a massive increase of consumption.

One way to reach this goal would be to reduce the costs involved in long-range transportation. It is the aim of this paper to analyze the problems and prospects in this connection. Main emphasis is put on the supply of markets in the industrialized countries of Western Europe from distant producing areas in the Americas, South East Asia and Africa.

Commodity properties

Avocados. There exists a very great number of avocado varieties with widely varying storage properties. They are divided into three main races – the Mexican, the Guatemalan and the West Indian – and a number of hybrids between the races.

The stage of maturity at harvest is of critical importance for successful storage of avocados. The optimum picking maturity is considerably influenced by the length of storage intended. In any case, too immature fruits must be avoided as they tend to be inferior in flavour and texture on subsequent ripening. Attempts to develop objective methods for determining picking maturity, e.g. determination of oil content, specific gravity or impedance, have so far not been entirely successful (Stahl, 1933; Bean, 1962; Emilsson, 1969). Presently, resort must generally be taken to such criteria as size, shape and colour, evaluated on the basis of local experience.

Avocados are sensitive to chilling but the critical temperature varies very much between varieties. Some varieties are subject to injuries after 15 days at 11.7°C, while others are not damaged by extended storage even at 0°C. Various manifestations of chilling have been observed; for a detailed description see Emilsson (1969).

Chilling in avocados, as in many other fruits, is a complicated phenomenon in which several factors are involved. In addition to variety, temperature and duration of storage the maturity of the fruit at the time of storage is of critical importance. The evidence available indicates that fruits are most susceptible to chilling during the initiation of ripening.

The optimum storage temperature for avocados is largely determined by the critical limit for chilling; generally it should be as close to this as possible. Consequently, the storage temperature to be chosen varies very much between varieties. For most commercially important varieties it is in the range of 4.5°C to 12.8°C.

Generally, the storage life is considerably longer for cold-tolerant varieties than for the cold-intolerant ones. For the best keeping types an economical storage life of 3 - 6 weeks, in exceptional cases even 8 weeks, may be expected. It appears that one primary condition for successful long-range marketing of avocados is to find varieties with optimum keeping properties, which at the same time have satisfactory consumer quality.

There is some experimental evidence that the storage life of avocados may be extended considerably by the application of CA-storage (Overholser, 1928, Wardlaw and Leonard, 1935; Biale, 1941; Hatton and Reeder, 1965). Wardlaw *et al* (1935) found some varieties to be surprisingly tolerant to CA conditions and it is interesting to note that in this category are varieties highly sensitive to chilling and consequently not suited for transport at low temperature.

Avocados are highly liable to attacks by microbial diseases during storage. Some of these infect the fruits in the plantation but remain dormant and cannot be detected at harvesting. The injuries develop during storage and ripening and may cause very serious losses. There appears to be a large need for more efficient methods to control these diseases.

Mangoes. There are at least a thousand different varieties of the mango with highly varying characteristics and commercial value (Singh, 1960).

The choice of the stage of maturity at picking is of critical importance. Unfortunately, considerable difficulties have been encountered in the search for suitable methods for this purpose. Criteria useful for one variety may not be valid for others. Generally, selection is based on shape, size and colour of fruits. Attempts have been made to use the sugar and acid content, the colour of the pulp, the number of days after blooming, the specific gravity etc.

Mangoes are very susceptible to chilling. Injuries may manifest themselves as skin blemishes, failure to ripen normally on removal from cold storage and a marked decline in resistance to pathogens. Susceptibility to chilling varies with variety, season and picking maturity. The critical temperature for chilling is for many varieties 7.2°C to 8.9°C; some varieties tolerate temperatures as low as 1.7°C (Emilsson, 1969). There are wide differences between mango varieties with regard to optimum storage temperature and to storage life. Several commercially important varieties store best at 5.6°C to 8.9°C and may reach an economical storage life of 4 - 7 weeks. Some evidence is available indicating that mangoes may benefit from CA-treatment (Kapur *et al.* 1962).

The problem of waste due to microbial attacks is difficult in mango storage. Damage due to wound parasites may be serious but can be well controlled by careful handling of the fruit. Apart from this, mangoes very often, though apparently sound and unblemished on picking, may carry latent infections of a number of different pathogens (Singh, 1960), causing anthracnose or other types of rots. Disease incidence during ripening, attributable to such dormant infections, is greatly accentuated by chilling, prolonged cold storage and slow ripening. Disease wastage may be considerably reduced by well-timed fungicidal treatments prior to harvesting.

Pineapples. The number of commercial cultivars of the pineapple is considerable. According to Py and Tisseau (1965), they may be classified into four main groups: Cayenne, Queen, Spanish and Abacaxi. Size, colour, storage properties and other characteristics of the fruit vary considerably between and within these groups.

Flavour and aroma are most attractive in pineapples fully ripened on the plant. Such fruits, however, are not adapted to extended storage and transport and for this purpose a less mature grade must be selected. It is

necessary, though, that a certain stage of maturity has been reached at harvesting, otherwise normal ripening may not take place and the final quality will be poor. Generally, the colouring of the skin is used for judging maturity, but this criterion is far from infallible. Additional criteria have been tried; these include the size of translucent zones around the eyes and the development of the crown, slips, eyes and bracts. Local study and experience is indispensable to determine precisely the most suitable harvesting maturity for particular requirements.

Generally, the optimum storage temperature is 7°C to 8°C. In this range ripening proceeds very slowly and fungal decay is kept fairly well in check. Lower temperatures cause chilling injuries – the fruits take on a dull hue, develop water soaking of the flesh and darkening of the core and are particularly subject to decay when removed from cold storage. At higher temperatures, on the other hand, ripening proceeds rapidly. Under optimum conditions the economic storage life for pineapples is 4 to 6 weeks.

CA-storage of pineapples has been little studied. It appears, though, that this method might open possibilities for long-range transport of fruits harvested at a more developed (coloured) stage, which may lead to greater consumer satisfaction.

Among microbial storage diseases, a rot caused by *Thielaviopsis paradoxa* (de Segnes) von Hohn is the most important. Control measures include rapid cooling immediately following harvest and disinfection of cut surfaces. There is some evidence that the storage life of pineapples may be prolonged by dipping the fruits in a wax emulsion. As a control measure against *T. paradoxa* a fungicide may be included in the emulsion.

The three kinds of fruits discussed here have a number of properties in common: of which the following are of special importance.

- the economic storage life is generally rather short – 3 to 6 weeks
- the fruits are liable to chilling injuries
- the optimum storage temperature is generally in the range 5 to 10°C
- the fruits are very liable to microbial storage diseases.

The need of more research

Our knowledge about the storage properties of avocados, mangoes and pineapples is still very limited. Surprisingly little first-class scientific work has been carried out on these fruits since the classical studies of Wardlaw and his collaborators. There is an obvious need of further research, fundamental as well as applied, on the storage physiology and technique of these fruits. The following aspects appear to warrant special consideration

- optimum storage temperature for different varieties and provenances
- development of methods – preferably non-destructive tests – for objective determination of picking maturity
- application of CA technique
- improvement of methods for control of storage diseases
- the importance and technique of precooling.

It is the author's opinion that no rapid expansion of world trade in fresh avocados, mangoes and pineapples is to be expected until our knowledge of these problems has been considerably improved.

Transport alternatives

During the last decade 'the development of air cargo has been almost explosive' (Nilsson, 1969). Thus, the volume of international air cargo has increased more than four times from 1960 to 1968. However, the air freight share in total cargo tonnage transported in the world –excluding bulk loads, which are unlikely to be flown in any event – is still only about 3%.

According to a recent estimate by the author more than 7 million tons per year of fresh fruits are carried by refrigerated ships. As compared to this figure the volume of fresh fruits transported by aircraft is still negligible.

The fresh fruits under consideration here have a fairly short storage life even under optimum conditions. Allowing 2 weeks of storage life for distribution and marketing there remains with the technique presently available generally only 1 to 4 weeks for intercontinental transport. The big advantage of air transport is speed. In most cases the transit time is counted in hours rather than in days.

For the commodities, production areas and markets under consideration here the time required for sea transport varies between a few days up to 4 or 5 weeks. In many of the potential trades the time involved in sea transit is either definitely too long or just about too long to give full guarantees for perfect arrival and sufficiently long residual storage life for successful marketing. However, there is a strong trend to higher speeds and shorter transit times. The introduction of different types of unit loads, including containers, also tends to shorten the transport time required. It is foreseen that this development will eventually put additional sea trades within the time limits required.

IATA 'specific commodity rates' for air transport of fresh fruits from the Americas, South Africa and India to the European continent presently are in the order of 500 - 800 US $ per ton. Somewhat lower rates may be obtained by special charter arrangements. Conference rates for sea transport of fresh fruits on the trades mentioned above range between 35 and 135 US $ per ton, i.e. only between 5 and 25 percent of the air freight.

Air transport is usually of short duration and flights are at an altitude where the temperature of the atmosphere is not very high. Arrangements for closer control of the temperature in the cargo holds are generally lacking. It is suggested that it might be worthwhile to study the possible advantages of applying a more advanced technique in this respect.

The technique of refrigerated sea transport of fruits has reached a high level. Modern reefer vessels are equipped with efficient installations for maintaining the

cargo at optimum condition with regard to temperature and a number of additional factors.

Air freights today are too high to allow for any really large expansion of trade in fresh avocados, mangoes and pineapples carried over long distances. A freight cost of 500 to 800 US $ per ton is reflected in the retail price with 1.000 to 1.600 US $ per ton. When the F.o.b. price of the fruit and mark-up on this are added the resulting retail price clearly places the goods in the luxury category.

Future development of air freight costs is difficult to judge but most authorities appear to agree that no drastic reduction may be expected during the next decade. It is foreseen that trade in air transported avocados, mangoes and pineapples will continue to increase at a moderate rate. Especially for avocados and mangoes this may be expected to stimulate consumer interest and appreciation, thus paving the way for a massive increase in the consumption could cheaper produce be made available. There are bright prospects for such a development could the technique of sea transport be improved to guarantee perfect arrival and enough remaining storage life.

Problems in Maritime Transport

One important difficulty facing the development of marine transport of avocados, mangoes and pineapples concerns quantities. Generally, cargo quantities of at least 500 tons, mostly 1,000 tons and upwards, are required to induce a modern, fully refrigerated ship, which is not in liner service, to call a port of loading. When liner service is available, a call of port may be scheduled regardless of cargo quantity. However, for various reasons – temperature requirements, risks for ethylene damage – the kinds of fruits discussed here may not be carried in the same cargo space as the bigger staple items among fresh fruits (bananas, citrus, apples, pears, grapes). Therefore, it will nevertheless be indispensable to have enough produce of the same kind available to fill one cargo hold, generally 50 - 100 tons, which may be an obstacle in the initial stage of development of a new trade. The introduction of transport in reefer containers may offer an easy solution to the quantity problem. A standard 20 feet container holds about 10 tons of fruit, which appears to give sufficient flexibility even in the initiation period.

Preliminary work has indicated that the storage life of avocados, mangoes and pineapples may be extended considerably by the application of CA-treatment. Much more research work is needed before the practical value of such treatment may be definitely evaluated. Nevertheless, it appears tempting to speculate on the potential use of CA in marine transport of these commodities.

So far the CA-technique has been used to a very limited extent only in ocean shipping. Actually, only the fairly recent introduction of the externally generated atmosphere technique has made ocean transport of fruits in CA a proposal of real practical interest. The arrival of the reefer container makes the possibilities still more realistic (Emilsson, 1969).

The evidence available tends to indicate that the application of CA-treatment, especially in combination with container transportation might well lead to a major improvement in the marine transport of the fruits under review here.

Avocados, mangoes and pineapples are very liable to damages by bruising. Therefore, they must be packed in such a way that they are adequately protected against mechanical influences during transport. Several quite good types of packaging have been developed for pineapples. One especially attractive solution features vertical packing in cardboard cartons with special inserts to fix the fruits in position. A very wide variety of packages is used for avocados and mangoes. It is felt, though, that there is need and possibility for much improvement in the packing of these fruits.

Mechanical damage in ocean transport occur mainly in the handling of individual packages during loading and unloading operations. They may be largely eliminated by using container transport from door to door, the container being loaded at the plantation and carried unbroken all the way to the wholesale dealer. This allows for a much simplified packing. The method has proved very successful in some trades, e.g. from San Juan and Hawaii to USA.

Before and after transport

The condition and quality of the fruit at the time of loading are of paramount importance for the transport outturn. A few of the influencing factors will be briefly reviewed.

A first essential is standardized production under plantation or orchard conditions. Special emphasis must be put on the control of diseases which infect the fruits during growth and manifest themselves later during storage.

As already indicated the choice of the correct stage of maturity at harvest is essential. Fruits must be precooled immediately after harvest and then brought into transit without delay. Any intermediate storage as well as transport to loading ports should be under controlled temperature conditions.

Careful grading to established standards ensures ready acceptance on the receiving markets. Packing must be carried out in such a way that the fruits are adequately protected against mechanical damage during the whole journey to the final destination.

The handling between harvesting and shipment to the consumer markets thus involves a series of operations: grading, sizing, sometimes washing and chemical treatment (fungicides, waxes etc.), packing, precooling and intermediate storage. It may often be advantageous to centralize all these operations to a packing station. Such units afford possibilities to mechanize all operations to the fullest extent and to provide adequate facilities for precooling and intermediate storage. Qualified technical personnel may be employed, contributing to uniformity and high quality of the produce.

Proper handling of the fruits from their arrival at the unloading port until they reach the final consumer is a further essential.

Just as for bananas, it appears desirable to develop a special ripening and distribution technique for avocados, mangoes and pineapples. Difficulties may be considerable but it is believed that the marketing of these fruits would benefit materially from finding ways to satisfy the demands of the consumer for optimum ripe fruits with full flavour and aroma.

Efficient sales promotion, informing the consumers about the qualities of these 'new' fruits and the best way of using them could play a big role in expanding their markets.

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Discussion

Dr. Lowings: Is it in fact viable at the moment to consider containers out of smaller developing countries? If not, is there any hope of obtaining other shipping? Does Mr. Hales think it is of immediate urgency to develop techniques to carry out fruit from the country using old boats fitted with modern refrigeration?

Mr. Hales: There is no technical reason why this should not be done. One physical limitation is that conventional cargo ships are not designed to carry containers. Most ships can carry a limited number of containers on deck. The real difficulty is that of economics. It is possible to hire a refrigerated container for a relatively short period of time. The cost is about $14 per day for a 20 ft. container taking about 10 tons. Given that the return freight will pay for the shipment within the container, the shipment back and for the rental of the container there should be no reason why most cargo ships should not carry a small number of containers. You may in addition have to put a power supply on them.

Mr. Candia: I hope that by some form of co-operation it may be possible to continue to provide an outgoing cargo to relieve the costs of the return of the containers.

Mr. E. G. Hall: To comment on the question of container service to small ports. We have been doing quite a lot of work on packaging in sealed plastic film. In-package atmosphere control could be very useful in the export of small consignments of tropical fruits in refrigerated holds in ships. This can be achieved to a satisfactory level by the use of sealed plastic film bag liners. In Australia we have had very good results with bananas, even kept at 25°C, especially when an ethylene absorbent is used. Results with some other fruits are encouraging and the method is worthy of much more study.

Sr. Pantin: ¿ Qué sistema se emplea par las inspeciones sanitarias cuando se emplea el transporte de furgones?

Mr. Hales: As I indicated, reorganization is needed for an effective container service. In this country there have been established a number of inland container centres where there are Customs and Public Health Inspectors available. I imagine much would depend on what the fruit is and what the health inspectors think they might find. With apples, for example, it is usual to take one container out of a batch for inspection. Basically, there is no trouble.

Mr. Goldenberg: In connection with the moisture in the cartons for canned goods, what is the dangerous percentage of moisture?

Mr. Hales: We have found moisture contents up to 10% in containers and there have been no problems. We would like to know what is the absolutely safe percentage but are not certain yet.

Mr. Odoi: Mr. Brown raised a very pertinent point on transport costs. He referred to the refusal of IATA to reduce cargo rates for fruits. Our planes often arrive at British and Continental airports with cargo capacity to spare. We are not allowed to charge lower than IATA rates, but for our fruit shippers these rates are too high. What suggestions have the FAO or others at this Conference to give which will help in obtaining preferential air freight charges for tropical fruit?

Mr. Candia: I am glad that you raised this question. It should be taken up with IATA, who, I am sure, would at least discuss it. It is difficult, if not dangerous to say anything here.

Mr. Brown: Basically, airfreight rates are likely to remain stable or rise. The airlines are not currently prepared to introduce break points for high rates or higher tonnages, because they have not the capacity to carry more than a few tons. I feel that in the near future we will not see a decrease in airfreight rates by IATA carriers. Much more of the produce will be carried by the charter air companies.

Third Session

Tuesday 16th September
Morning

Chairman
Monsieur R. Deullin
Institut français de recherches fruitières outre-mer, Paris

Storage and transportation of Florida citrus fruits

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Summary

Florida citrus fruits must be harvested at the proper maturity or ripeness if good quality is to be maintained during storage, transport, and the subsequent market period.

Storage of early harvested fruit requiring ethylene degreening is not recommended. Degreened fruit should be exported with caution because of the potential for increased decay and rind breakdown.

Prior to storage or shipping, citrus fruits should be treated with a recommended fungicide and wax to prevent decay and excessive loss of weight and moisture.

Air precooling, but not hydrocooling, is recommended for rapid removal of field heat.

Temperatures, relative humidity, and length of storage have been recommended for the stoiage of Florida citrus fruits. Controlled atmosphere storage has been found to reduce rind disorders and maintain the fresh appearance of fruit but often increases decay.

Refrigerated transport of Florida oranges is recommended to reduce decay. Grapefruit may be exported under ventilation during the winter months. A daily 15-minute ventilation of refrigerated container vans and ships' holds is recommended.

Introduction

The purpose of storing fruits and vegetables is to extend their availability to the consumer and provide for more orderly marketing. Successful storage is attained by providing environmental conditions which reduce the respiratory activity of these living agricultural products and inhibit the growth of decay-producing organisms while maintaining quality. Storage of citrus fruit is often complicated by the fact that prolonged holding at low temperatures may induce physiological disorders, result in off-flavours, and change the mirco-flora that normally cause decay.

This paper is concerned primarily with those prestorage treatments and storage environments which affect the condition and quality of Florida citrus fruits during storage, transport, and their subsequent market period.

Prestorage factors affecting keeping quality

Quality and Harvest

Citrus fruits do not ripen nor does the quality improve after harvest; therefore, the maturity or ripeness of the fruit at harvest is important. Immature fruit usually are very tart with ricey and coarse internal texture. Overripe fruits become insipid, develop off-flavours, and have short transit, storage, and shelf life (Harding, Winston and Fisher, 1940, Harding and Fisher, 1945). The approximate shipping seasons for Florida citrus fruits are shown in Fig.1.

Few studies have been made on the most appropriate harvest dates for Florida citrus fruits that are to be stored. Based on United States Department of Agriculture storage trials from 1960 to 1968, suggested harvest dates for storage of Florida citrus fruits are as follows: Valencia oranges, March; Temple oranges, January; Murcott Honey oranges, February; Orlando tangelos, December; and Marsh and Ruby Red grapefruit, March-April.

Smoot (1969a) found that the incidence of decay increases as the fruit becomes riper. Also, according to Chace (1969), storage of Valencia oranges for 16 weeks at 1°C plus one week at 21° made the effect of ripeness

quite evident. Fruit harvested in March developed 7% decay, whereas comparable fruit harvested in May developed 43% decay. Chace, Harding, Smoot and Cubbedge (1966) reported that early harvested grapefruit are most susceptible to pitting, with susceptibility to pitting gradually decreasing as the fruit becomes more mature. Ageing and decay are serious problems with over-ripe fruit.

Degreening

Several varieties of citrus fruits grown in Florida mature internally before the rind colour becomes acceptable to the consumer. Poorly coloured mature fruit are treated with ethylene gas to destroy the chlorophyll in the rind. This degreening process often has an adverse effect on citrus fruit. Grierson and Newhall (1960) reported that the ethylene degreening process increases decay about 2.5 times. Rind injuries of grapefruit and oranges also are increased by the ethylene treatment. For these reasons, storage of degreened fruit is not recommended. Importers should be aware of these potential problems during September to December, when most fruit is degreened.

Prime quality oranges and grapefruit degreened by ethylene for short periods can be stored successfully for 3 to 4 weeks without excess loss. Chace *et al* (1966) reported less than 2% decay in early harvested grapefruit during a simulated export transit period of 3 weeks at 15°C. This fruit was degreened for 36-46 hr.

Precooling

Florida citrus fruits usually are precooled by air cooling or hydrocooling. Air cooling, the most common method, is accomplished in refrigerated rooms or transport vehicles. Winston and Cubbedge (1959) recommended that oranges be room-precooled to below 4.5°C prior to export. Refrigeration facilities aboard most ships or in container vans do not have sufficient capacity to cool citrus fruits rapidly.

There is still some question about the value of hydrocooling citrus fruits. Grierson and Hayward (1960) reported that decay was inhibited initially but increased during the marketing period. Decay during shelf life is increased in fruit hydrocooled in plain ice water. Addition of sodium o-phenylphenate to hydrocooling water inhibits decay somewhat but not to the level of that found in non-hydrocooled fruit (Smoot, Grierson and Kaufman, 1960). Hydrocooling is not recommended for citrus fruit that is to be exported or placed in long-term storage.

Waxing

All Florida-grown citrus fruit is washed before storage or transport; waxing is mandatory to replace the natural wax removed by washing. Waxing prevents shrinkage and weight loss and increases consumer appeal by making the fruit glossy. Proper application of wax has been reported to prevent weight loss (Hopkins and McCornack, 1964) and extend the storage life (Ben-Yehoshua, 1967) by at least 50%.

Fungicides

Losses from decay have been a serious economic problem in the marketing of fresh Florida citrus fruits. All citrus fruits moving from the State of Florida are required by law to be treated with an approved fungicide. Three fungicides are now approved by the US Food and Drug Administration for use on citrus fruits: sodium o-phenylphenate (SOPP), thiabendazole (TBZ), and biphenyl (diphenyl).

Hopkins and McCornack (1959) compared the relative effectiveness of a number of methods for control of citrus fruit decay. Table 1 presents part of their experimental data, representing the decay-control treatments most frequently used by the industry. Percent decay control due to treatment is based on the percentage of decay in the untreated controls. TBZ was approved in 1969 for use on citrus fruits, and the percent decay control is based on 1 year's data (Smoot, 1969b). These preliminary results indicate that TBZ shows good promise as an effective fungicide to control decay of citrus fruit during transit and storage. Other fungicides with greater potential for decay control are under test by various experimental agencies but must await approval by the Food and Drug Administration before being used commercially.

Table 1

The relative effectiveness of fungicidal treatments for control of decay in oranges after 2 weeks at 70°F. (Hopkins and McCornack, 1959)

Treatment	Average percent decay control*
Sodium o-phenylphenate (2%) + hexamine (1%)	70
Diphenyl-impregnated pads (2 pads, 2.35 g/pad)	82
Sodium o-phenylphenate + diphenyl-impregnated pads (2 pads, 2.35 g/pad)	95
Thiabendazole (1,000 ppm)	90†

* Percent decay control

$$= \frac{\text{\% decay in control} - \text{\% decay in treatment}}{\text{\% decay in control}} \times 100$$

(Hopkins and McCornack, 1959).

† Unpublished data on Hamlin, Pineapple, and Valencia oranges during the 1968-1969 season (Smoot, 1969b).

Storage requirements

Temperature

With the proper use of refrigeration during storage or transportation, the external appearance of citrus fruit is maintained, flavour can be retained, and physiological breakdown and decay minimized. The recommendations for storage of Florida citrus fruits are presented in Table 2.

Table 2

Recommendations for storage of Florida citrus[1]
Relative humidity 87-92%

Variety	Storage temperature	Length of storage period
	°C	Weeks
Dancy tangerines	4	2 - 4
Orlando tangelos	4	4
Temple oranges	4	4
Murcott Honey oranges	1	6 - 8
Valencia oranges	1	8 - 12
Grapefruit	10	6 - 8
Limes	9	6 - 8

[1] Revised from Lutz and Hardenburg (1968).

One of the major roles that refrigeration is expected to play is to prevent decay in fruit. The amounts and kinds of decay which develop during storage and subsequent marketing period are related to (1) variety of fruit and season, (2) temperature and duration of storage, (3) atmosphere during storage, and (4) postharvest treatment (Smoot, 1969a).

Two species of fungi cause most of the decay of citrus during the storage and subsequent marketing. *Phomopsis citri* Fawc. is the causal agent of most stem-end rot, and *Penicillium digitatum* Sacc. causes green-mold rot which follows mechanical injuries to the fruit. Other fungi which are observed are *Alternaria citri* Ell. and Pierce, and *Penicillium italicum* Wehmer, *Colletotrichum gloeosporioides* Penz., and *Geotrichum candidum* Link ex Pers.

The development of decays in response to temperature can be seen in Fig. 2 (Smoot, 1969a). When Orlando tangelos were held for 5 weeks at various temperatures plus one week at 21°C, green-mold rot (*Penicillium*) decreased and stem-end rot (*Phomopsis*) increased as the temperature increased. Orlando tangelos often suffer chilling injury at 1°C so that *Penicillium* develops on the injured fruit during the one-week 21° holding period.

Control of decay during the storage of Florida citrus fruits is not resolved simply by holding at the recommended temperature. For instance, the year-to-year variation in susceptibility to decay in Valencia oranges held in controlled atmosphere (CA) and air storage is shown in Table 3. Although the time of the long storage periods differed between 1966 and 1967, the fruit in 1967 was apparently less susceptible to decay than the fruit in 1966. This disparity in results between years is apparent in all types and varieties of citrus fruits and presents difficulties in evaluating the effects of prestorage treatments and storage environments on decay control. Refrigeration may aid in preventing decay but also may cause additional problems. Studies with Florida grapefruit showed, as early as 1920, that breakdown or pitting of the rind resulted from holding this fruit too long in cold storage (Hawkins and Magness, 1920). Low-temperature injury of Florida oranges has been reported by Stahl and Camp (1936), Harding (1949), and Chace and Harding

Table 3

The effect of atmospheric concentration, length of storage, and year of harvest on decay of Valencia oranges (washed + fungicide + wax) held in CA and air storage at 1°C plus one week at 21° (Chace, 1969)

Atmospheric concentrations	Year of harvest and length of storage			
	1966		1967	
	12 weeks	20 weeks	12 weeks	16 weeks
	Pct.	Pct.	Pct.	Pct.
21% O_2 + 0% CO_2 (Air)	20	72	1	1
15% O_2 + 0% CO_2	8	50	2	3
15% O_2 + 2.5% CO_2	6	86	3	2
15% O_2 + 5% CO_2	10	83	2	4
10% O_2 + 0% CO_2	2	41	3	8
10% O_2 + 2.5% CO_2	6	85	7	6
10% O_2 + 5% CO_2	13	63	2	1

(1962). The choice of an optimum temperature must, of necessity, be a compromise between prevention of decay, which occurs more readily at high temperatures, and prevention of physiological disorders, which occur at low temperatures.

Proper temperature is important for retention of flavour (Fig. 3). Temple oranges, held for 5 weeks at various temperatures plus one week at 21°C, were compared with fruit left on the tree for the same time. The flavour of the nonstored overripe fruit was sweet and insipid, lacking the normal aromatic constituents. Fruit held at 4.5°C retained good flavour; it too, however, lost some of the aromatic constituents.

Table 2 gives recommendations for the length of the storage period for Temple oranges. Longer storage often leads to development of off-flavours and loss of quality.

Relative humidity

Relative humidity of 87%-92% is recommended for storage of Florida citrus. Wells (1962) emphasized the importance of temperature and relative humidity in relation to weight loss. He stated that at a given temperature, during postharvest handling and storage, fruit lose moisture at rates which vary inversely with relative humidity. Weight loss, however, varies directly with temperature.

Aside from the maintenance of appearance and weight during storage, relative humidity is definitely related to the incidence of rind breakdown of citrus fruits (Miller, 1946). Low relative humidity accelerates the rate of development of low-temperature injuries of oranges, grapefruit, limes, and lemons. More pitting of grapefruit has been reported at low humidity (50%-75%) than at high (90%-100%) (Brooks and McColloch, 1936, Pantastico, Soule and Grierson, 1968).

The success of controlled atmosphere storage of apples has lead to considerable interest and some exploratory research as to its feasibility for use on Florida citrus fruits (Grierson, Vines, Oberbacher, Ting and Edwards, 1966, Chace, Davis and Smoot, 1967, Davis, Chace and Cubbedge 1967, Chace, 1969, Smoot, 1969a).

Atmospheres used for storage of apples were found to be unsatisfactory for citrus fruits. Valencia oranges held in 15% O_2 + 0% CO_2 for 12 weeks at 1°C, plus one week in air at 21°, had higher flavour ratings than similar fruit held in other controlled atmospheres or in air. Flavour was impaired by a further decrease in O_2 and an increase in CO_2. However, no combinations of O_2 or CO_2 which maintained fruit quality prevented subsequent decay. Generally, decay increased as the levels of CO_2 increased. When Valencia oranges were stored 12 to 16 weeks in controlled atmospheres, decay was caused largely by *Alternaria,* spp., *Colleotottichum,* spp., and *Penicillium,* spp.

Grapefruit held in 15% O_2 + 5% CO_2 at 7°C for 12 weeks, plus one week in air at 21°, retained fair to good developed less decay, pitting and ageing than similar fruit held in other atmospheres or in air.

Temple oranges held in 10% O_2 + 5% CO_2 for 10 weeks at 4.5°C, plus one week in air at 21°, retained fair to good flavour. These fruits, however, lacked the distinctive aromatic constituents normally associated with the Temple orange.

Citrus fruits stored in controlled atmospheres were firmer, lost less moisture, and had a fresher appearance than comparable fruit stored in air.

A preliminary experiment with storage of Temple oranges in nitrogen showed no differences in flavour of fruit after 14 days when compared with fruit stored in air. After 21 days, however, fruit held in nitrogen developed off-flavours.

Transportation

The same prestorage and environmental requirements should be used whether Florida citrus fruits are stored or held in a refrigerated vehicle being transported to market. With domestic shipments requiring only 2 to 5 days, it may be impossible to attain the recommended temperatures. However, this section does not deal primarily with domestic shipments but with the specific problems of export shipments.

The two methods of exporting Florida citrus fruits are as 'break-bulk' cargo in the ship's hold and in container vans. With both types of transportation, the load can be shipped either ventilated or refrigerated. Oranges in most test shipments under ventilation developed more decay than similar fruit in refrigerated loads (Hatton and Winston, 1958, Winston and Cubbedge, 1959). During the winter months, when the ambient temperatures are between 10° and 15.6°C, Florida grapefruit can be shipped under ventilation. In April and May, however, refrigerated loads of grapefruit developed less decay than ventilated loads (Hatton and Winston, 1958, Chace *et al,* 1966, Harding, 1967). Refrigeration is recommended for export shipments of all citrus fruits, however, high temperatures during the first 5 days of transit, poor air circulation in vented holds, and lack of humidity controls are deterrents to shipping citrus fruits in ventilated holds.

Air precooling of Florida citrus fruits is recommended although not often applied. The slow rate of cooling in container vans has been noted by Hinds and Chace (1962) and Johnson (1967). Winston and Cubbedge (1959) found that refrigeration facilities aboard most ships can lower the temperature of the cargo only 1-2 degrees a day. Chace *et al* (1966) found that in refrigerated holds it took about 3 days for the cargo to reach 10°C. Johnson (1967) also found that refrigerated containers were not capable of rapid cooling of grapefruit during transit. Once the cargo has reached the desired temperature, the refrigeration facilities are able to maintain temperatures within 3-5 degrees of the thermostat setting.

A daily 15-minute ventilation of container vans or refrigerated holds is recommended. Johnson (1967) reported that after 7 days the atmosphere in a container of Texas grapefruit contained 9.3% oxygen and 10.0% carbon dioxide. Chace *et al* (1966) reported that carbon dioxide increased from 0.2% to 1.3% in 4 hours in a refrigerated hold containing Florida grapefruit.

Florida citrus fruits are shipped in either fibreboard cartons or wirebound crates; however, neither container provides adequate physical protection during export (Chace *et al,* 1966, Harding, 1967). The cartons are weakened by the absorption of moisture so that, when stacked 10 to 12 high in the ship's hold, the bottom cartons and fruit are often damaged.

The key to good air circulation, uniform temperatures, and reduction of damage is knowledge of the air-circulation system, a good stacking pattern, and proper bracing.

Conclusions

Florida citrus fruit for transport or storage requires careful harvesting at optimum maturity followed by proper application of a fungicide and wax. The environmental conditions in storage must be controlled carefully in order to avoid chilling injury, development of excessive decay, and loss of flavour. Each type or kind of citrus has specific environmental requirements.

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Figure 1
Approximate commercial shipping seasons for Florida citrus fruits (Harding *et al*, 1966).

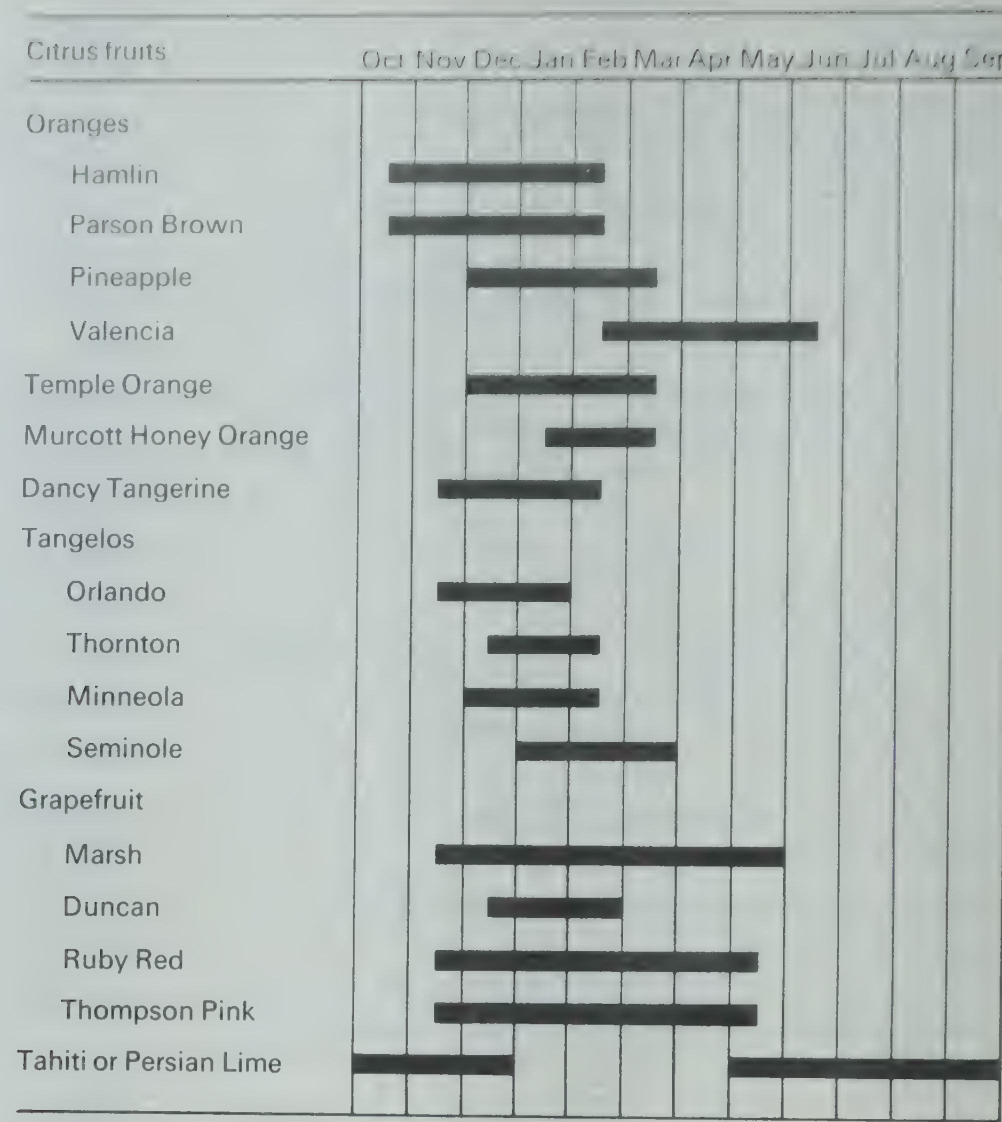


Figure 2
Effect of storage temperature on type of decay development on Orlando tangelos. 5 weeks plus 1 week at 21°C (1966) (Smoot, 1969a).

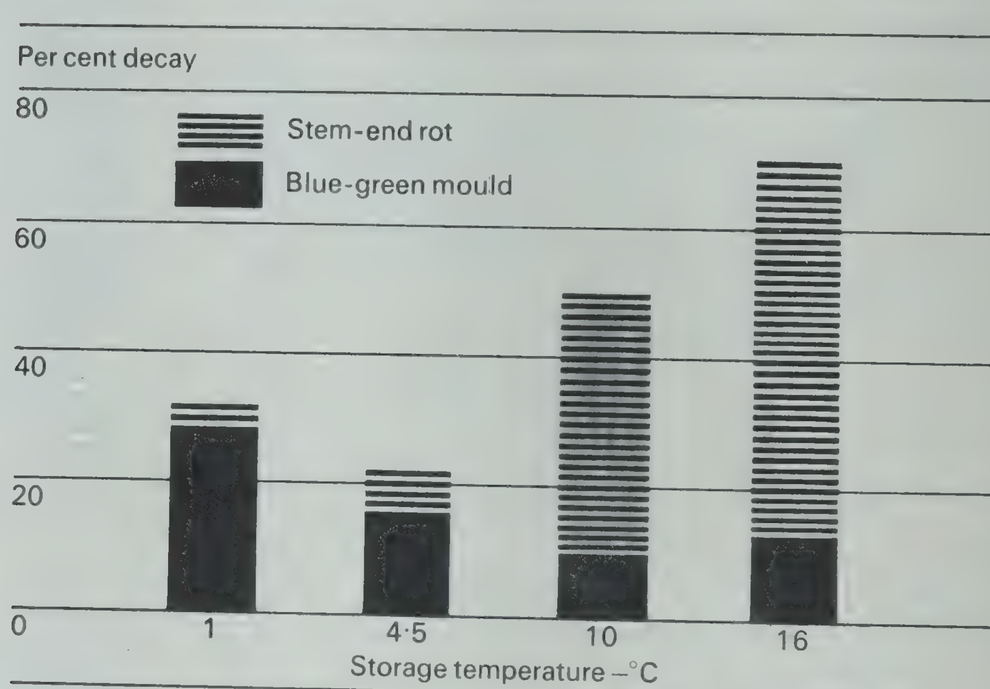
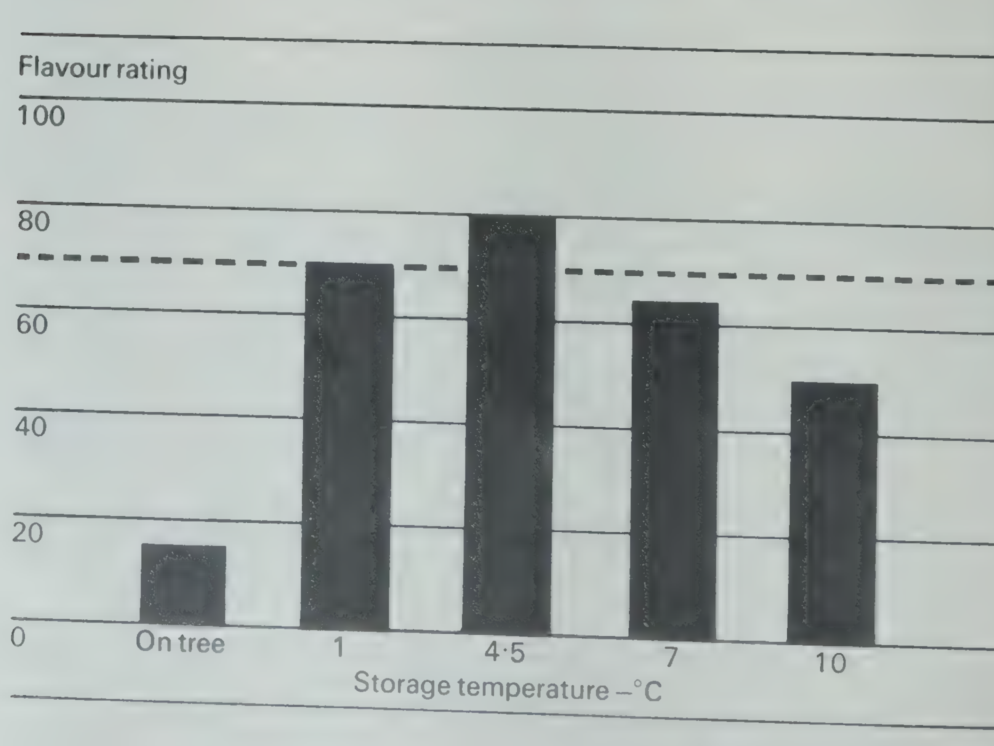


Figure 3
Flavour ratings of Temple oranges held "on tree" and in air for 5 weeks plus 1 week at 21°C. A rating of 70 indicated minimum acceptable flavour (Adapted from Chace, 1969).



The airfreighting of fruits, with particular reference to tropical countries

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Summary

The increasing use of air transportation in recent years for the distribution of perishable commodities has focused attention upon the prospects for using this method of transport for the export of fruit, particularly highly perishable tropical fruits, which do not ship successfully by sea. This paper has been prepared to fill a need for information on the various aspects which must be considered when sending fruits by air.

The advantage of the aeroplane, when compared with other forms of transport, is its speed, and this enables highly perishable fruits to be sent over long distances without excessive deterioration and for fruits to be harvested closer to their optimum stage of maturity for eating. However, because of its relatively high cost its use is currently confined to those fruits which will make comparatively high prices on the wholesale markets of the importing countries, for example, out-of-season strawberries, or exotic fruits such as pineapples, avocados and mangoes.

The advantage of the speed of air transport can be lost if the grower, exporter and shipper do not follow good handling and packing practices and maintain the fruits in an environment which will reduce deterioration to a minimum. Procedures are outlined for maintaining quality during transit.

The increasing use of air transportation in recent years for the distribution of perishable commodities has focused attention upon the possibilities of using this method of transport for the export of fruits from tropical and subtropical countries, to markets such as, the United Kingdom, Western Germany, France, Sweden, Switzerland and Canada. The use of airfreight often appears attractive to those countries where only relatively small quantities of fruit are at present available for export and there is difficulty in obtaining regular refrigerated cargo space for the journey by sea.

The importation of airfreighted fruits into the United Kingdom began in the early nineteen fifties, when small spasmodic consignments of various items such as mangoes, avocados, pineapples and out-of-season strawberries arrived on the London market. By the mid-nineteen fifties, Kenya had started to send commercial consignments of pineapples by air, together with odd parcels of certain other fruits, such as strawberries, passion fruits, mangoes and avocados, while several other countries began to explore the possibilities of developing a market for airfreighted fruits. As aircraft have increased in size and speed and there has been a downward trend in freight charges, an increasing number of countries in the tropics and subtropics have attempted to send consignments of fruit by air to the United Kingdom and other markets in Western Europe. As regards the United Kingdom, a feature of the fruit trade in the last five years has been the dynamic expansion that has taken place, not only in the overall tonnage of fruit sent by air, but in the variety of fruits offered. However, many of the attempts by individual exporters in the tropics to develop a viable export trade in airfreighted fruits have not been commercially successful and this paper has been prepared in order to fill a need for information on some of the practical aspects connected with the airfreighting of fruits and the development of a viable export trade. Although only fruits are considered, it should be mentioned in view of the growing trade in airfreighted vegetables, particularly during the winter and early spring months, that many of the points discussed apply equally as well to other types of horticultural produce.

Compared with road, rail or sea, air transportation is expensive, even with the growing use of charter planes,

but it offers the advantage of speed, when compared with other forms of transport. It is the speed of the aeroplane which makes it particularly attractive for the carriage of many tropical fruits, which because of their perishable nature cannot normally be shipped over long distances without excessive deterioration. In addition, it is also possible to send fruit which has been picked closer to its optimum stage of maturity for eating, than when other more slower forms of transport are used. The improvement in the quality of the fruit marketed, not only results in increased returns to the shippers, which can materially offset the extra freight charges incurred, but it has also been found to increase the demand for and acceptance of unfamiliar fruits, when attempts have been made to introduce these to new markets. For example, there is a growing demand on the United States mainland for Hawaiian papayas, due to the improvement in the quality of the fruit, now that it is almost exclusively sent by air.

At present, however, the use of airfreight is largely confined to those fruits which can be grown in the tropics and subtropics and which because of their speciality nature, or because they can be produced during the normal out-of-season period in temperate countries, can consistently make high prices on the wholesale markets of major importing countries. In addition, air freight can be used to rush supplies of fruit to a market at the very beginning of the season, when high prices can normally be obtained for a very short time. A typical example of this trade is the supply of early grapes from Israel, Turkey and other parts of the Eastern Mediterranean, which are flown to the United Kingdom market in late June and early July, at the very beginning of the Mediterranean grape season. Of the out-of-season fruits, strawberries are the most important and fresh strawberries are now available in all the major wholesale markets of Western Europe throughout the year. During the winter months supplies are obtained from several countries including Kenya, New Zealand, the southern United States and Mexico. Of the tropical fruits, pineapples, avocados and mangoes are the most important items sent by air at present and because of their novelty value normally make comparatively high prices, when compared with the more commonplace fruits such as apples, pears, oranges and bananas. In addition, considerable quantities of certain types of melons, such as the Israeli Ogen are sent by air to European markets.

Impulse buying through self-service stores and a less conservative attitude towards new foodstuffs, combined with the increased number of people from the tropics now living in the United Kingdom, is tending to increase the demand for tropical fruits. With a rising standard of living in most Western European countries there seems no reason why the demand for pineapples, avocados and mangoes should not expand and a demand for many more tropical fruits such as papayas, lychees, passion fruits, mangosteens, custard and star apples and perhaps even more exotic items, such as rambutans, should not be developed, since these fruits could be successfully sent by air, provided that reasonable precautions are taken to avoid deterioration during transit and distribution.

The demand for airfreighted fruits is currently confined mainly to the upper and upper-middle income groups and most of the fruits are regarded as luxury or semi-luxury items. For this reason quality, good packing and an attractive appearance are of the utmost importance; buyers in the wholesale markets of the importing countries are extremely discriminating, because in many instances they are purchasing fruit for consumers who are prepared to pay comparatively high prices for novel or exotic items, provided that the quality meets their requirements. At present a high proportion of the airfreighted fruit arriving on the United Kingdom market is purchased for use in hotels or restaurants. In many instances buyers are only interested in quality and appearance and price is of secondary importance. It is therefore essential that exporters should only send fruit which will arrive at its destination in first class condition and inferior fruit should be rejected before it is packed. Freight charges form the major cost item of most airfreighted fruits and since this is a fixed charge over which neither producer nor exporter has any control, it is essential that the fruit should make the best posssible price on the wholesale markets of the importing countries. The difference in the price obtained for first quality fruit and fruit of only slightly inferior quality can be considerable, when the demand is confined to a relatively narrow section of the market, yet the exporter has had to pay identical freight, packing and handling charges.

All the advantages of the speed of air transport can be lost if the grower, exporter, carrier and receiver do not all follow good handling practices and keep deterioration to a minimum. All fresh fruits remain living and metabolically active throughout their period of saleability and during this period continue to respire and to utilize the reserve foods stored during growth. Respiration is accompanied by changes in the composition of the fruit resulting in changes in quality and eventually in spoilage. Although the metabolism cannot be stopped completely it should be slowed down if the quality is to be retained and the aim of good handling practices, even with airfreighted fruits, should be to provide the most suitable environment, which will reduce the metabolic activity to a minimum and yet keep the fruit alive.

It is well known that the market quality of all fruit is controlled by a time-temperature relationship and that the rate of deterioration for most fruits is increased by as much as four times for every 10°C. rise in temperature. It is therefore obvious that rapid deterioration can occur if the fruit is left standing in tropical temperatures of 30°C. or more, for even a short period, such as in the field or on the tarmac of the airport. Serious deterioration can occur if the fruit is placed in the cargo space of an aircraft that has been left standing in the hot sun for any length of time. Not only does high temperature accelerate ripening and deterioration, but it also favours the development of decay. The activity of the organisms causing decay is also accelerated by high temperatures in much the same way as the respiration rate and thus, the reduction of temperature as soon as possible after the fruit is harvested is of the utmost importance in order to maintain the quality of the fruit. Pre-cooling and the use of insulated containers is an obvious solution to this

problem, but with many tropical fruits pre-cooling to temperatures of between 0°C. and 5°C. is not practicable, because of the risk of chilling injury. Chilling injury results in shortened shelf life and usually the chilled fruit suffers from skin blemishes, internal discolouration, increased susceptibility to decay and a failure to ripen. The temperature and length of exposure required to cause chilling injury in tropical fruits varies according to variety and growing conditions, but it is generally recommended that cold-intolerant fruits such as certain varieties of avocados, papayas, and mangoes, should be pre-cooled to a temperature of around 13°C., and if possible maintained at this temperature during transit. Cases of chilling injury have been observed, when certain fruits have been exposed to low temperatures at high altitudes during a very long flight, but nowadays the flight time is normally so short that protection from the packing material used is usually sufficient to prevent the occurrence of chilling injury. However, exporters intending to send some of the lesser known varieties of tropical fruits by air, should determine their susceptibility to chilling injury and provide some form of insulated container. In most cases the use of a protective layer of wood wool has been found to be effective.

All fruits lose water by evaporation after harvest, which can result in a loss of their fresh appearance and serious wilting can result. The rate of water loss is determined by the temperature of the product, the temperature and relative humidity of the atmosphere, the extent of air movement, the atmospheric pressure and the nature of the fruit itself. It can be minimized by maintaining the fruit in an atmosphere with a relative humidity of between 85 and 95 per cent. In the case of airfreighted fruit it must be remembered that reduced air pressure accelerates the rate of water loss and its prevention can be of considerable importance in the maintenance of quality during flights at high altitudes.

The successful development of an export trade in airfreighted fruits begins with the grower, as when other forms of transport are used. In order to produce first class quality fruit free from all blemish marks, disease and insect infestation, the grower must be able to organize his production on scientific lines, using modern techniques to control insect pests and diseases. Harvesting must be carefully controlled so that the fruits are picked at the correct stage of maturity, so that they arrive at their destination in the optimum condition for eating and yet have an economic shelf life for retail distribution. Careless handling during harvesting and subsequent grading and packing is one of the primary causes of spoilage, since whenever the skin of a fruit is damaged spoilage will start immediately. The use of clippers, rather than pulling, is recommended for fruits such as avocados and mangoes, and the finger nails of the pickers should be kept as short as possible so as to minimise the danger of skin punctures from this source. The labour force should be trained to handle fruit carefully so as to avoid bruising. Two common causes of bruising are the workers dropping the fruit carelessly into the picking boxes or baskets, or applying too much pressure when handling the fruit. Sometimes bruise marks of the thumb and forefinger can be seen on pineapples on display at Covent Garden market. Whenever possible the fruit should be harvested under dry conditions and in the coolest part of the day. Before packing, the fruits should be sorted and accurately graded for size and maturity, so that there is no noticeable variation between the individual fruits in any one package. With many fruits the maturity that results in the best eating quality is too advanced for the fruits to be carried satisfactorily over long distances and there is usually some compromise between carrying and eating quality. This is particularly the case with many tropical fruits, which are metabolically very active and which have to be harvested very immature when sent by land or sea to overseas markets. Little or no compromise should be necessary when these fruits are sent air cargo and therefore exporters should attempt to market fruits at an advanced stage of maturity, and whenever possible should work out their own standards of maturity, based on the experience acquired with trial shipments to import markets.

The packing of fruits sent by air is of great importance, and the operation requires careful supervision by experienced staff, as no amount of good packing material can prevent damage due to careless handling. The three major factors are the damage that can be caused by bad packing, the appearance of the product at its final destination and the cost of the packing operation in terms of labour and material. Once again it must be emphasized that the fruit with the best appearance on the wholesale markets of the importing countries, will normally be sold first and at the best price. Most people purchase fruit by sight, on physical appearance, colour, lack of blemishes and damage, the arrangement of the individual pieces in the container and the overall appearance of the carton. Although it is essential to use lightweight containers when sending fruits by air, weight must not be sacrificed at the expense of rigidity and the protection of the contents. The container must have an attractive appearance and be able to withstand a considerable degree of mechanical stress and have sufficient strength for stacking. In many instances the use of single layer cardboard containers, sometimes reinforced at the corners with wooden cleats and with ventilation holes to prevent the contents from sweating during the journey, has proved to be satisfactory. In view of the fact that the demand for most tropical fruits is at present limited, it is advisable for exporters to use packages of 5 or 6 kilo net weight for many items. The important exceptions to this are pineapples, which are packed upright in compartmentalized cartons, containing 4, 6 or 8 fruits, and certain small fruits, which are often packed in punnets. Whatever size of container is used it is important that it should appear full. A container that does not look full, even if it contains the correct weight has a poor sales appeal, since the purchaser receives the impression that he is getting short weight. All packages should be clearly labelled, with the type of produce they contain, weight and/or number of pieces, country of origin and where applicable the variety and grade.

In the packing operation care must be taken to avoid damage. One of the factors that can cause damage is

packing the fruits so that they come in contact with one another, which can cause skin damage and bruising when the fruits rub against one another during the journey. One of the best methods to reduce the likelihood of damage from this cause is to wrap each individual fruit in tissue paper, which acts as a protective cushion. Serious damage can be caused if the fruits are packed too tight or too loose. When packed too tight, they exert pressure on one another, which can cause bruising, even with relatively firm fruits, such as avocados. If the fruits are packed too loosely, the motion during transit can cause them to rub against one another which results in bruising.

As has already been discussed, the perishability of many tropical fruits and the fact that lightweight containers are used when they are sent by air, increases their susceptibility to damage due to rough handling during transit and at airports. In recent years considerable progress has been made in the development of unitized pallet loading and unit containerization, in an attempt to eliminate the multiple handling of small cartons. Recently, a small shipping unit consisting of an aluminium framework, covered with foam plastic, and having a capacity of 13 cubic feet, has been developed in the United States for the air freighting of perishable commodities. This could be used satisfactorily for tropical fruits packed in standard size containers.

In recent years the time the fruit is in the air has been considerably reduced by the use of faster planes and the organization of ground handling is assuming greater importance. It is essential that the harvesting, packing and delivery of the fruit to the airport are well organized, so that all operations are carried out with the minimum of delay. At the airport the provision of holding rooms where the fruit can be stored for short periods, under controlled temperature and humidity is desirable.

On arrival at the importing country similar arrangements for handling the fruit with care and speed are essential, if the quality is to be maintained. Some exporters have now begun to employ agents who specialize in the handling of perishable commodities sent by air, since these usually have facilities for quick and efficient handling and distribution of the produce.

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Biosynthesis of ethylene and its control

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Summary

Ethylene, a plant hormone, initiates the sequence of chemical reactions which occur in ripening fruits. If its synthesis can be prevented or retarded the onset of ripening will be correspondingly delayed.

The ability of unripe bananas to synthesize ethylene is dependent on the oxygen tension of the atmosphere surrounding the fruit. Unripe bananas do not synthesize significant amounts of ethylene at 18°C unless the oxygen tension is above 7.5-8.0%. At oxygen tensions of 10-13% synthesis does occur but it is delayed compared with fruit in air. It has been demonstrated that delay in the onset of the ripening syndrome occasioned by holding fruit in 5-7.5% oxygen is caused by their inability to synthesize ethylene. The ripening syndrome may, however, be initiated even in atmospheres of low oxygen by the inclusion of exogenous ethylene in physiological concentrations. Once the sythesis is initiated, the fruit are capable of producing ethylene even in atmospheres of low oxygen.

From the food technologists' viewpoint there are three stages in the life history of many fruits; the first, the development stage, or preclimacteric phase; the second, the ripening stage, or climacteric phase; and the third, the onset of senescence, the postclimacteric phase. In the first phase, the fruit remains firm and green, whilst attaining its adult size. In the second phase, the changes associated with ripening occur and lead eventually to senescence and final disintegration.

From the standpoint of preservation of the fresh fruit, which in effect means extending the shelf life, the objective must be to arrest, or at least retard, the changes associated with the last two phases. It is in this area that the plant physiologist has provided an answer. The initiation of the second, the climacteric phase, depends on the production of ethylene by the fruit. The hydrocarbon produced in greater or less degree by all fruits, is a plant hormone which initiates the changes we associate with ripening. It is a stimulant which is the cause of the change from a stage of relatively low to one of high metabolic activity. In bananas for example, the respiration may increase tenfold and bring in its train many chemical changes.

It is clear from these remarks that control over the biosynthesis of ethylene is all important if we wish to extend the duration of the preclimacteric phase, for by so doing, we shall increase the storage life and availibility of fruit to the consumer.

With this objective in view, the ideal state would be to arrest competely the onset of the climacteric phase, but be able at will to initiate it when required, and so allow the subsequent ripening changes to follow. The problem thus reduces itself to a study of the conditions affecting the biosynthesis of ethylene.

During the past few years, our knowledge of the mechanism whereby ethylene is synthesized *in vivo* and the substrate from which it is derived, has increased to some extent, although many questions still remain to be answered. In these biochemical studies, its formation from methionine has been indicated and for one tissue (cauliflower florets) the enzyme and co-factors involved defined (Mapson, 1969). To date the reactions may be summarized as follows. (Fig. 1)

A consideration of these reactions indicates the absolute need for oxygen for the production of ethylene in these reactions. The essential role of oxygen in the synthesis of ethylene from intact fruit was first demonstrated by Gane (1935) and has been confirmed by many other workers for other plant tissues, pears (Hansen, 1942); broccoli (Lieberman and Spurr, 1955); tomatoes (Craft, 1968).

It is, of course, impossible to hold fruit in an oxygen-free atmosphere for any length of time without causing physiological injury although such a procedure would eliminate any synthesis of ethylene. However, it is possible to reduce the oxygen tension of the storage atmosphere to such a degree that, whilst allowing sufficient respiratory activity to prevent physiological damage, arrest, or at least considerably retard, the synthesis of ethylene. This technique, which was originally enshrined in the well-known controlled atmosphere storage of apples, was originally proposed not so much as a means of controlling ethylene as a means of preventing the climacteric rise in respiration. For this reason the inclusion of CO_2 was considered to be essential in combination with low oxygen (Kidd and West, 1933). More recent research has indicated (Burg and Burg, 1965) that the chief cause of the retardation of ripening in fruit depends on its ability by CO_2 to competitively inhibit the stimulatory action of ethylene.

The experiments I wish to describe are concerned more specifically with the effect of reducing oxygen in the storage atmosphere, on the synthesis of ethylene and on the related phenomena of respiration and onset of ripening in bananas, (Mapson and Robinson, 1966) although we have more recently extended these experiments to cover other fruits, notably tomatoes, cucumbers, etc. with very similar results.

We have been able to show (1) the synthesis of ethylene in amounts sufficient to induce ripening is controlled by the tension of oxygen in the atmosphere, and (2) that both the initiation of the synthetic process and the synthetic process itself are dependent on the level of oxygen in the atmosphere, and (3) that ethylene *per se* is the factor which induces both the accompanying respiration climacteric and associated ripening changes.

Experimental

Material

Banana fruit of two varieties were used, *Lacatan* from the West Indies and *Gros Michel* from West Africa. In each experiment the samples consisted of three or four connected fingers taken from a single hand of bananas.

Methods

The fruit were placed in containers (~6000 ml in volume) and a constant stream of the appropriate gas mixture passed through at an average rate of approximately 700 ml/hr. Samples of emerging gas were taken for estimation of ethylene and CO_2. All experiments were conducted at 18°C.

Carbon dioxide was determined by absorption in soda-lime and samples of gas for ethylene, taken before passage over soda-lime, were analysed by gas chromatography technique using a flame ionization detector as described by Lieberman, Kunishi, Mapson and Wardale, (1965).

At the termination of each experiment the fruit were sampled for appearance, taste and flavour. It was, of course, impossible to compare at the same time the eating quality of control fruit with the experimental fruit held in low oxygen since these ripened at a much later date. Fruit were therefore assessed on the basis of whether they were to be considered of good eating quality.

Results

When full 'three-quarter grade' but unripe green bananas are held at a ripening temperature (18°C), in atmospheres in which the oxygen level is reduced to a value of 1-7%, the ripening process is prevented or retarded as long as the fruit is subjected to the low oxygen. The results of an experiment in which the fruit was held in 6, 10 and 13% oxygen and in air are illustrated in Fig. 2.

The fruit held in the lowest oxygen showed no signs of ripening, as measured by either production of ethylene or rise in respiration, for 27 days. On return to air, within 4 days stimulation of the production of ethylene was observed, which reached a peak 2 days later. The respiration climacteric rise began 24 hr after that of ethylene. Although atmospheres of 10-13% oxygen delayed the rise in the rate of the synthesis of ethylene and the associated respiratory changes, they did not prevent these occurring. There is therefore a threshold concentration of oxygen below which a marked synthesis of ethylene does not occur. This threshold appears for bananas to be in the region of 7.5% oxygen at a temperature of 18°C. In this experiment, it will be noted that these changes occurred slightly earlier in the fruit held in 10% oxygen compared with those in 13% oxygen. We do not attach any significance to this difference but believe it to be due to variation as between individual fruit.

A similar experiment carried out at a more elevated temperature (32.5°C) yielded the same results. (Fig.3) In this case,the rise in ethylene at the climacteric in air was even more rapid, and this was also reflected in a very rapid rise in the respiration, followed within a few days by a complete breakdown of the tissue. No ethylene was produced above the trace amounts normally found in the preclimacteric fruit in 3% oxygen, and the respiration declined to a value of about one-third of that of the preclimacteric state in air. The fruit was held for 14 days at this tropical temperature, and if returned to air at 20° the normal climacteric rise and ethylene and respiration occurred and the fruit ripened to a good quality. It will be noted that in both this and the preceding experiment, the increase in the synthesis of ethylene always preceded that of the increase in respiration by a time interval from 12 to 15 hr as the temperature was increased from 18 to 32.5°C. Experiments with

other fruit, notably tomatoes and cucumbers, have given similar results. Results of an experiment with tomatoes is illustrated Fig. 4.

Ethylene as inducer of the ripening process

The concept that ethylene functions as a ripening hormone was first put foward by Kidd and West (1928). This concept was challenged by Biale *et al* (1954) who suggested that the gas was merely a by-product of the ripening process and not its initiator, on the basis that certain fruits showed that climacteric rises in respiration can occur without any detectable production of ethylene.

In our experiments with atmospheres of low oxygen we have been able to arrest completely the ripening process, but have shown that, provided ethylene at physiological concentration is included in atmospheres of low oxygen, the respiration climacteric and the ripening changes of colour, texture and flavour may be induced. Jamaican bananas (Lacatan) in the green condition were exposed to atmospheres containing 5% oxygen in nitrogen and held at 18°C; fruit held in air were set up as controls. The fruit, as in the experiments above, were placed in a container through which a slow stream of the appropriate gas mixture (~500 ml/hr) was passed; no perceptible sign of ripening was observed. After 6 days, during which time the level of respiration (CO_2 production) was measured, ethylene (2.5 ppm) was incorporated in the gas stream passing over each one of the fruit samples held in air or 5% oxygen in nitrogen. As the results (Fig. 5) indicate, both samples responded by showing a respiration climacteric, although the rate of increase in the respiration in the 5% oxygen sample was slower compared with that in air and only reached a maximum value of about 75% of the rate in air. The sample left in air alone showed a climacteric rise in respiration after 12 days, but owing to somewhat uneven ripening (one finger started to ripen on twelfth day, others delayed until 17-18 days) the CO_2 production showed no distinct peak. The sample left in 5% oxygen alone showed no sign of ripening (no increase in respiration) even after 30 days, and at the end of this period was transferred back to air. Even then it did not show any signs until after the elapse of a further 19 days, when it ripened and gave a good eating quality fruit. The long period of delay, occasioned by the low oxygen atmosphere, had not had, therefore, any detectable deleterious effect on quality, as measured by colour, flavour and texture.

The results of this experiment clearly indicated that the sojourn in the low oxygen retarded or prevented ripening, by its effect on the suppression of the biosynthesis of ethylene, and not by the inhibition of the associated respiratory changes. Although these latter were depressed in rate by low oxygen and were accompanied by slower changes in colour, texture and flavour usually associated with ripening, the fruit did eventually become eating ripe.

In a repeat of this experiment, (Fig. 6) ripening changes in fruit held in 6.5% oxygen could be induced by the inclusion of 2.5 ppm of ethylene in the atmosphere. This result could be achieved even if the fruit was exposed to this concentration of ethylene for only 24 hr, and the onset of ripening was not further accelerated if the fruit was held for longer periods with ethylene. Analysis of the ethylene formed showed that after initiation of the synthesis by exogenous ethylene, endogenous ethylene was produced in appreciable amounts by that fruit even in low oxygen.

These experiments appear therefore to indicate that the prevention of ripening by holding fruit in low oxygen is due to the inability of the fruit to produce ethylene above the rate normally observed in preclimacteric fruit. It is true that both the rate of endogenous production of ethylene and the development of the other changes associated with ripening, induced by the application of exogenous ethylene, occur less rapidly under conditions of low oxygen. Nevertheless, the fact that they proceed at all suggests that the effect of low oxygen in arresting as opposed to retarding ripening in preclimacteric banana fruit is due primarily to its effect on the process of initiation of ethylene synthesis rather than to a direct effect on the synthetic mechanism.

Sensitivity of tissue to ethylene

There is some evidence that changes in the sensitivity of the tissue to ethylene may also be a factor in inducing the climacteric and onset of ripening. Burg and Burg (1965) observed that as preclimacteric banana fruit ages the sensitivity of the tissue to exogenous ethylene increased until at the climacteric the fruit reacted to a quantity of ethylene that it contained throughout the preclimacteric phase. The authors also point out that alteration of the tissue's sensitivity to ethylene must be a factor since immature and mature fruit on the tree contain 0.2 ppm of ethylene in their tissues, whereas after harvesting this intercellular level is sufficient to initiate the climacteric response. Furthermore, some tropical fruit, e.g. mangoes, ripen at the climacteric without any abrupt increase in their rate of ethylene production (Biale *et al,* 1954, Burg and Burg, 1962). With most fruits, however, there is evidence of some increase in ethylene production just prior to the onset of the climacteric rise in respiration. However, since in many fruits the respiratory response to ethylene whether formed endogenously or applied exogenously, takes time to develop (~12 hr in bananas at 18°C), it is not possible to state unequivocally whether the climacteric rise in respiration is normally initiated by an increasing production of ethylene or whether it is due to an increase in the sensitivity of the tissue to levels of ethylene normally found in the preclimacteric state.

Our own experimental observations support this concept of alteration of sensitivity to ethylene as a factor determining the onset of the climacteric. The threshold sensitivity of banana fruit to exogenous ethylene and therefore presumably to that produced endogenously, is increased in low oxygen. Thus in air, the climacteric rise in respiration may be induced by the application of ethylene in a concentration of 0.3 ppm in the atmosphere, but this was insufficient to initiate the climacteric in fruit held in low oxygen, and had to be increased

two fold before a response was obtained (Fig. 7). When less mature fruit was held in low oxygen, it required even larger concentrations of ethylene to induce ripening. In one experiment (Fig. 8) ethylene in a concentration of 2.3 ppm had to be applied before a response was achieved, although the fruit in air responded after some delay to ethylene at 0.33 ppm. Our results suggest, therefore, that low oxygen may arrest or delay ripening by its action on three physiological processes:

1. It maintains condition in the tissue such that the initiation of an accelerated rate of ethylene production is prevented;
2. It limits the rate of the synthetic process; and
3. it increases the threshold sensitivity of the tissue to the action of ethylene.

It is possible that processes 1 and 3 are really identical in that the condition which prevents an accelerated synthesis is the same as that which increases the threshold sensitivity. If sojourn in low oxygen increases the threshold sensitivity of the tissue to ethylene above that of the concentration normally present in the preclimacteric state, no initiation of the ripening process could occur until either the oxygen tension was increased or exogenous ethylene was applied. Once the threshold of ethylene concentration is exceeded, this brings in its train process which lead to a more rapid synthesis of the hydrocarbon and the system behaves in an autocatalytic manner (Kidd and West, 1945). Burg (1962) commenting on such phenonema claims that the increased synthesis of ethylene is one of the changes that ethylene itself sets in motion. Though this may be true, it throws little light on the mechanism involved. It is perhaps significant in this connection that several workers have established that ethylene induces the formation of peroxidase type enzymes (sweet potatoes –Gahagan *et al,* (1968), Imaseki *et al,* (1968); etiolated pea seedlings – Osborne, (1968)) and this enzyme has been implicated in the formation of ethylene from methionine *in vitro* (Mapson and Wardale, (1967); Yang, (1967)). However, other enzyme activities are increased under the stimulus of ethylene (malic enzyme and lipoxidase enzymes in apples – Hulme *et al,* (1968); polyphenol oxidase – Stahman *et al,* (1966)) and all these appear to be the result of new protein formation, since all are prevented by inhibitors of RNA and protein synthesis (cycloheximide and actinomycin). Thus the effect of ethylene on stimulating the formation of new enzymic protein, may lead to an increase in concentration of the enzymes actually concerned in the synthetic process of which peroxidase may be one. If such were the case, the autocatalytic features associated with the biosynthesis of ethylene in whole fruit would be explicable on this basis.

We as yet know very little about any biochemical changes which could account for the alteration of the sensitivity of the tissue to ethylene apart from any effect of CO_2. Interesting possibilities are the interaction with other plant growth factors. Thus in one field, it has been established that the action of ethylene in inducing abscission in leaves or inhibition of growth in seedlings, is counteracted by the level of auxin present. The physiological response in these cases appears to be due to a balance as between auxins and ethylene, and if the same applies to fruits it may well be that ethylene at the levels existing in the preclimacteric state cannot induce a physiological response until the level of other growth factors which restrain its activity have decreased. This latter process presumably occurs as the fruit matures.

Burg and Burg (1965), have suggested that the failure of fruits to ripen in low oxygen atmospheres is due to the inability of a receptor site to bind ethylene unless it is in an oxidised state. This receptor state is envisaged as containing a metal (Zn) which can be converted to an oxidised state by oxygen and to which ethylene attaches and through which it exerts its physiological action. It is difficult to see how this theory can account for the fact that the inhibition of ethylene biosynthesis and of the ripening changes by low oxygen in banana fruit can be relieved by the simple addition of exogenous ethylene. However, differences exist between different fruit in this respect for as Rhodes *et al* (1969) have shown, in the apple, addition of exogenous ethylene under such conditions does not stimulate either ethylene synthesis or ripening.

It is clear that further work is needed to establish the changes that precede and are the cause of the sudden and abrupt production of ethylene that occurs in many fruits at the climacteric, whether these be of a hormonal nature or otherwise.

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Figure 1
Reactions involved in the synthesis of ethylene in cauliflower florets

OVERALL REACTIONS

$$\text{D-CH}_3\text{-S-CH}_2\text{-CH}_2\text{-CH(NH}_2\text{)-COOH} + \underset{\text{(PHENYL PYRUVIC)}}{\text{OXO ACID}} \underset{\text{(PYRIDOXAL PHOSPHATE)}}{\xrightleftharpoons{\text{TRANSAMINASE}}} \text{CH}_3\text{-S-CH}_2\text{-CH}_2\text{-CO-COOH} + \underset{\text{(PHENYL ALANINE)}}{\text{AMINO ACID}}$$

$$\beta\text{-D-GLUCOSE} + \text{O}_2 \xrightarrow{\text{GLUCOSE OXIDASE}} \text{D-GLUCONO-}\delta\text{-LACTONE} + \text{H}_2\text{O}_2$$

$$\text{H}_2\text{O}_2 + \text{CH}_3\text{-S-CH}_2\text{-CH}_2\text{-CO-COOH} \xrightarrow{\text{PEROXIDASE}} \text{CH}_2 = \text{CH}_2 + \text{PRODUCTS}$$

PHENOLIC, SULPHINIC ACID

Figure 2
Effect of different levels of oxygen on ethylene production and respiration in bananas at 18°C

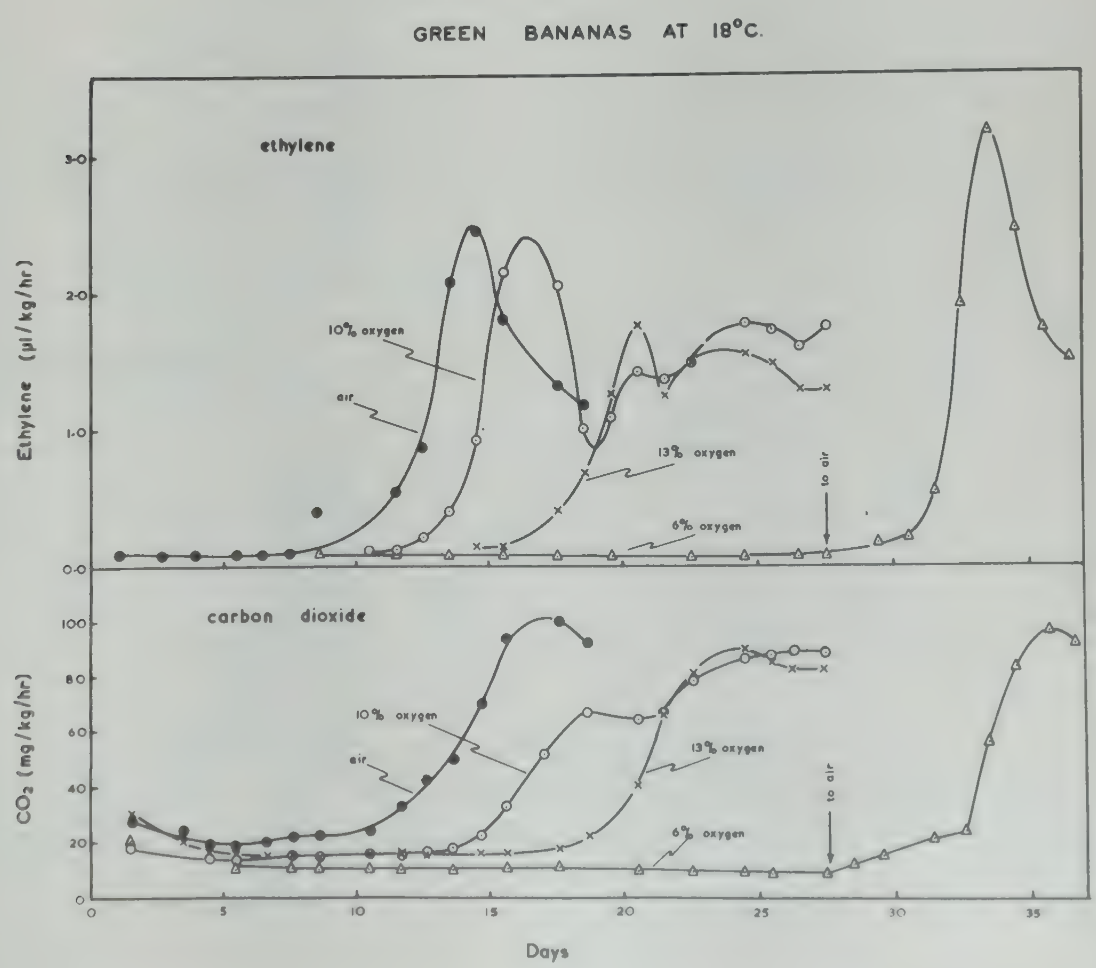


Figure 3
Effect of low oxygen on ethylene production and respiration at 32.5°C

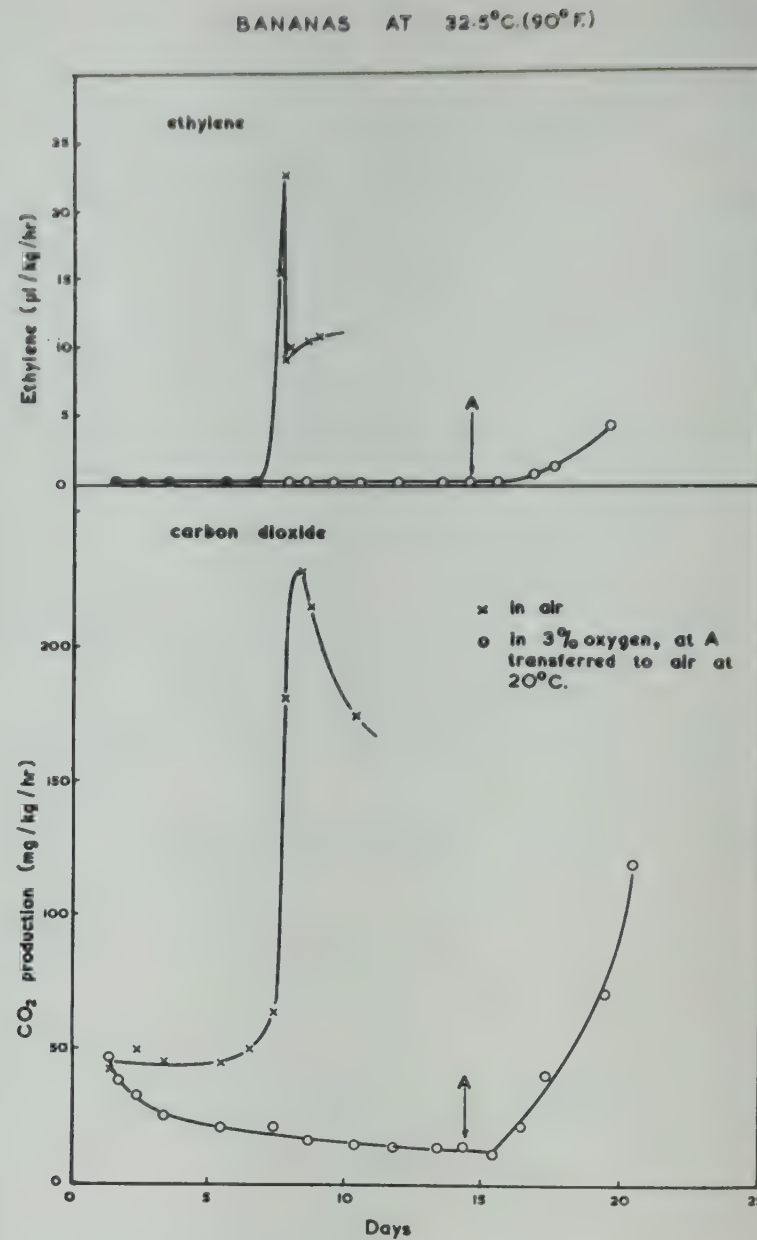


Figure 4
Effect of low oxygen on ethylene production and respiration in tomatoes at 18°C

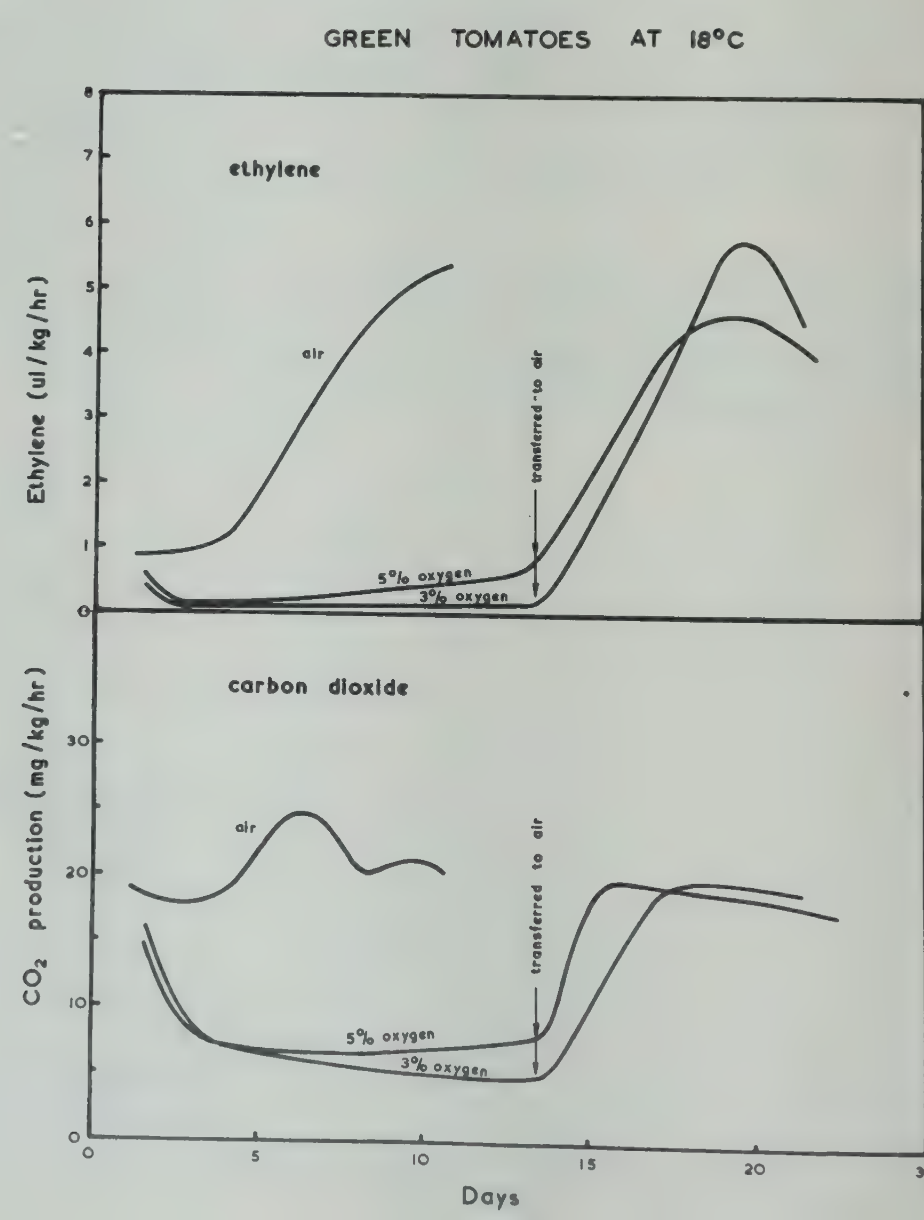


Figure 5
Induction of respiration climacteric in bananas held in air and low oxygen by exogenous ethylene

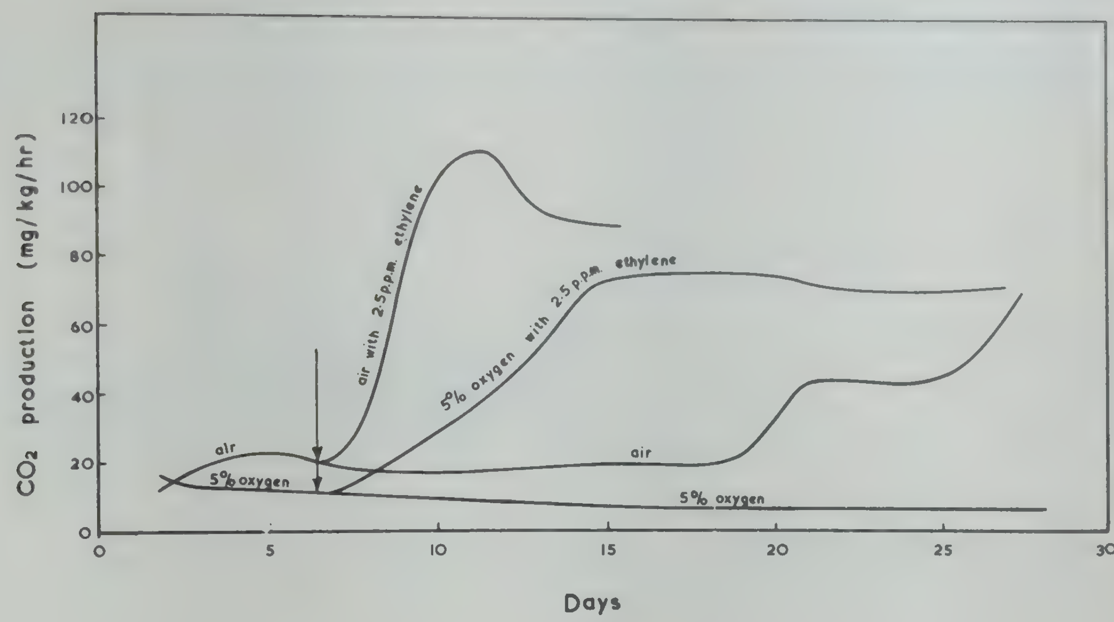
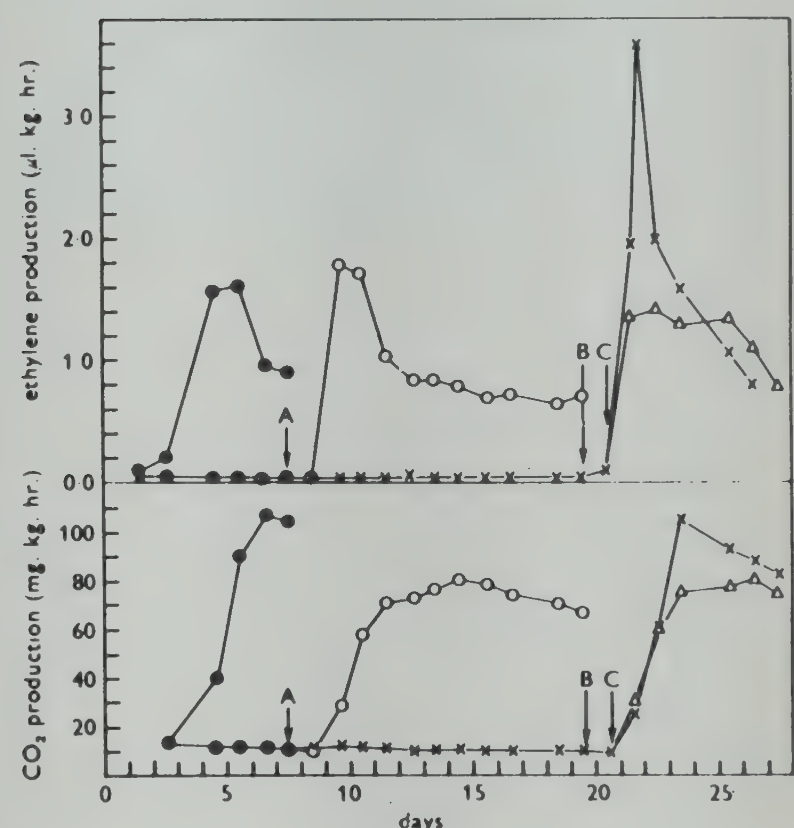


Figure 6
Induction of endogenous synthesis of ethylene in low oxygen by exogenous ethylene



● Air
○, × } 6.5% oxygen
○ at A ethylene 2.5 ppm
× at B ethylene 2.5 ppm
△ for 24 hr only
× to end of experiment

Figure 7
Respiratory response of fruit held in low oxygen to ethylene

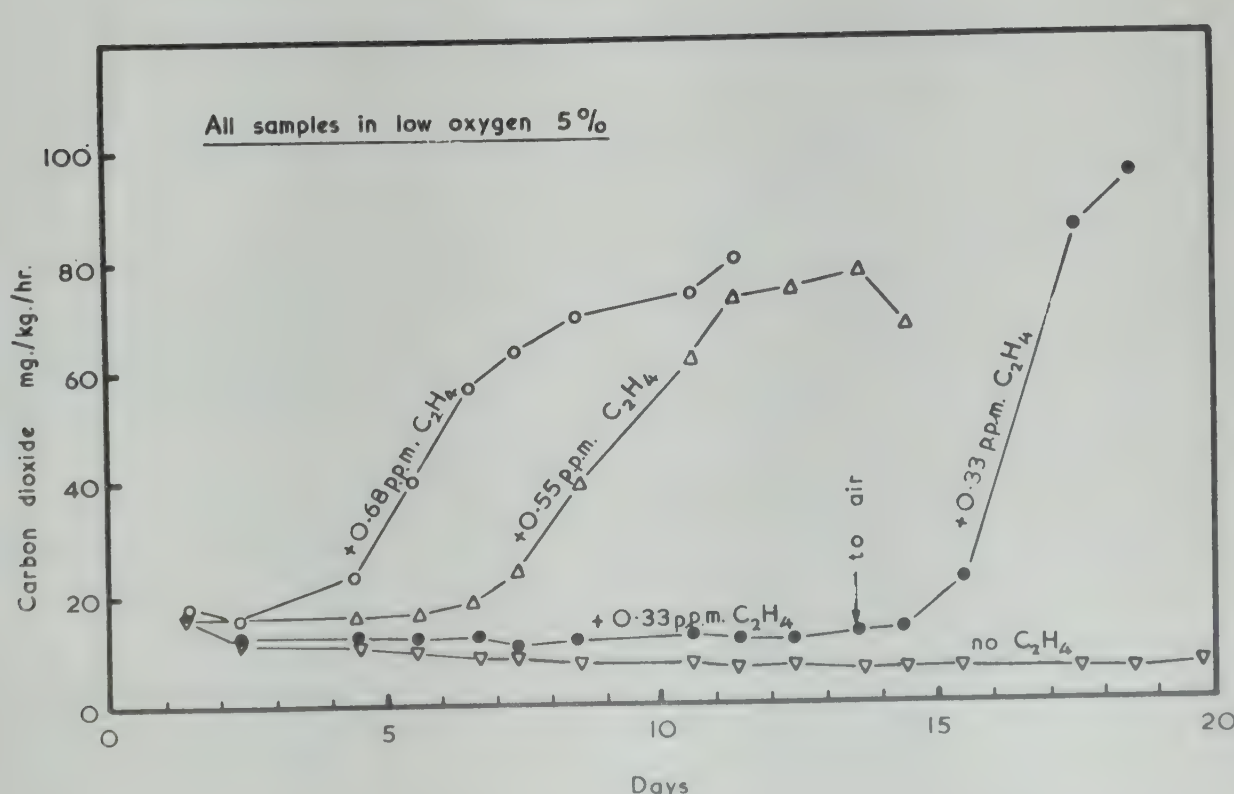
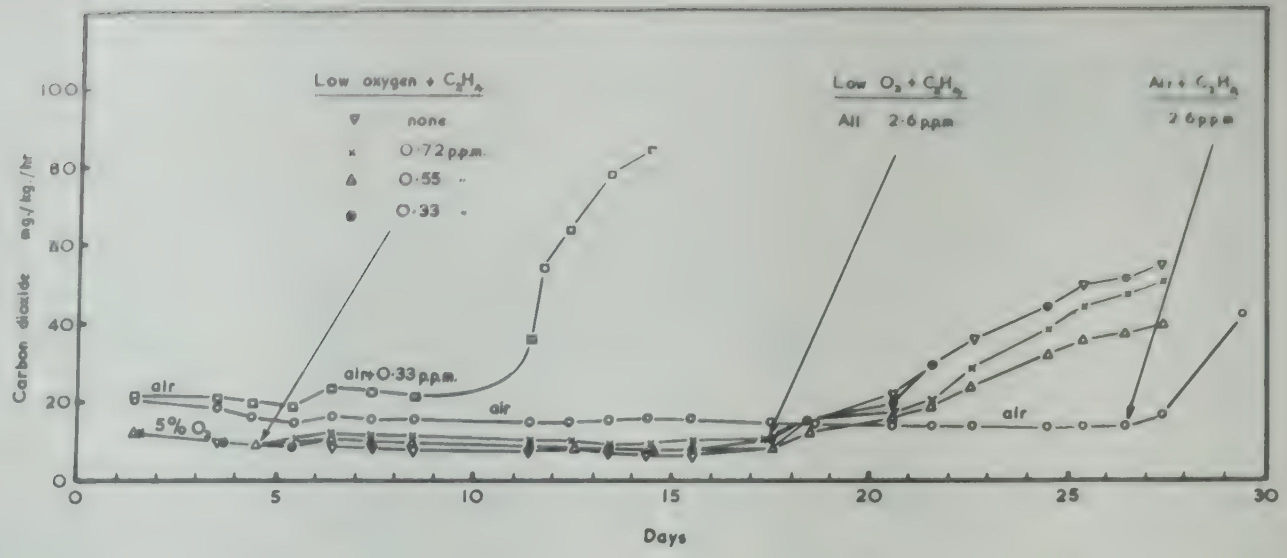


Figure 8
Respiratory response of immature fruit to ethylene



Banana conditioning during transport, without refrigeration

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Summary

Observations under laboratory conditions have demonstrated the possibility of chemically inhibiting the ripening of bananas at temperatures much higher than those of the traditional refrigerated transport. Two experimental shipments were made from Somalia to Italy.

The first experimental shipment of fruits dipped in a K_1 vitaminic emulsion, packed in plastic bags and cardboard boxes were shipped at temperatures of 20 and 30°C. On arrival in Italy, the experimental fruits were sent to Florence and placed in a commercial ripening room. Here the controls were rejected for over-ripeness and rotting, while the dipped fruits were a healthy green, and 33 days after treatment began to ripen normally in flavour and colour.

The second experimental shipment was made, loading, 300 cardboard boxes in metal containers, on the deck. This included 75 control boxes, 150 boxes containing vitamin K_3 treated hands and 75 boxes with K_1 treated hands. The transport temperatures were between 25 and 60°C. On opening at Naples, after a 19 day journey and 24 days after treatment, treated fruits were green while the non treated hands were over-ripe, rotting and fermenting. In the ripening room at Florence, a commercial assessment gave 53.4% of the K_1 and 36.0% of the K_3 treated hands normally ripened while, the remaining green treated fruits were rejected for an abnormal softness of the pulp.

Investigations were made to test the effects of vitamins K_1 and K_3 on cultures of *Gloeosporium musarum* Cke Massee and *Fusarium* sp. prope *moniliforme* Sh., which demonstrated a marked delay in conidification and in vegetative development of the mycelium.

Preliminary spectrophotometric analyses indicated residues of less than 2 ppm but more detailed investigations are needed.

Further experiments include the shipment of a whole compartment in a banana ship held at 16°C. filled with treated fruits together with a shipment not refrigerated but lightly ventilated.

Studies on the action of vitamins K_1 and K_3 on germination and growth of pure cultures of fungi and on respiratory metabolism of treated tissues are planned.

It is difficult to explain the action of the vitamin: it is probably acting as an inhibitor of electron transfer that it is able to stop or delay not only the Hill reaction but also several metabolic pathways, including those leading to the ethylene production.

Introduction

The commercial practice of fruit storage during transport is based upon a reduction of metabolic activity by control of the storage atmosphere. The resulting effects on metabolism are not strictly quantitative: it is known that the qualitative nature of respiration changes under refrigerated conditions and that physiological disorders may result from abnormal functioning of the respiratory mechanism in response to adverse external conditions. Beccari 1959. Ethylene is also less effective at low temperatures (Hansen, 1966). The use of refrigerated storage is limited by the temperature at which freezing or chilling injury occurs.

Lyons, Wheaton and Pratt (1964) found that susceptibility to chilling injury appears to be related to differences in the properties of the mitochondrial membranes: the membrane flexibility being influenced by many factors so that no batch of fruit is completely uniform. That means it is very difficult to find a temperature for transport which does not adversely effect some of the fruits. The use of controlled atmospheres as a supplement to refrigeration is now required for longer transport periods and improved maintenance of quality. The effects of low temperatures, and of modified concentrations of CO_2 and O_2, on the metabolic processes, cause changes in the marketability of the fruit, and this subject has received very little attention up to now.

Refrigeration of bananas during transport does not stop the metabolism of the fruit as a whole but slows down some phases of the metabolism and causes irreversible modifications in other phases that may affect quality. It also costs much more than a non-refrigerated transport. For these reasons my colleagues and I tried to develop a method to reduce the overall metabolic level over a limited period in order to avoid the metabolic disorders induced by chilling and, at the same time, to allow the use of cheaper non-refrigerated transport.

It is axiomatic that no metabolism can proceed unless energy is available and transferable. By acting on electron transfer, it should be possible to stop or delay any metabolic process.

This paper represents a preliminary report on this still largely unknown subject, which needs extensive further research.

Experimental methods and results

The work described here includes one experiment on fruits under laboratory conditions, six on shipments of treated fruits from Somalia to Italy, together with experiments on pure cultures of fungi and spectrophotometric analyses on the pulp of treated fruit.

The observations on fruits under laboratory conditions were made on bananas obtained from a dealer in Florence. These fruits had been harvested in Somalia 25 days before the treatment was applied, and had been shipped under normal refrigerated transport. This trial was only preliminary, and had the aim of verifying whether a metabolic influence of vitamin K, on green fruits close to climateric after a long period of refrigeration, could be detected.

The observations were made on 26 banana hands, originating from the same farm, of which 13 were treated and 13 untreated. The treatment consisted of dipping the hands for 5 min. in a 0-1% water emulsion of vitamin K_1, (2 methyl - 3 phytyl - 1, 4 napthoquinone). Vitamin K_1 is liposoluble and was emulsified by the use of 0.8% NN′-dimethyl-formamide (DMF) and 0.4% of the surface-active agent Sorbitan PQ 12. The bananas were kept in a climatic chamber at 25°C and 95% relative humidity. After three days, yellowing of the untreated hands began, while the treated fruits remained green for fourteen days. The complete ripening of all the untreated fruits occurred after seven days, and after twenty days in the case of the treated fruit (Fig. 1.)

A second experiment was organized involving the treatment in Somalia of freshly harvested bananas which were shipped to Italy in a non-refrigerated hold. Eighty hands were cut from 20 stems, from the same field at Farm no. 5, Copasso, Giuba, on February 25th, 1969. Four hands, from the second to the fifth were taken from each stem, 2 were treated and 2 were not. The 80 experimental hands were processed in the usual commercial way but the 40 untreated controls were packed at the end of the washing line, while the other 40 were dipped for 5 min. in a 0.1% water emulsion of vitamin K_1 with the addition of 0.8% of DMF and 0.4% surface-active agent, after washing. The samples were packed in polyethylene envelopes in 10 cardboard boxes and shipped in a non-refrigerated prow-hold of the M/S Golar Freeg, the next day. The ship reached Naples on March 14th, the temperature within the hold having been between 20° and 30°C. The day after arrival the boxes were inspected on the ship and then sent by non-refrigerated truck to a banana ripening room in Florence. When examined on 17th March, the 40 untreated hands were found to be grossly overripe, and to be affected by a general rotting due to *Gloeosporium musarum* Cke. Massee, *Fusarium* sp. prope *moniliforme* Sh. and other minor diseases. The treated fruits appeared to be healthy, still completely green with a firm pulp and showed very little rotting. In the ripening room 32 treated hands were exposed to normal ripening treatment together with fruits that had travelled on the same ship in refrigerated holds. The first yellowing appeared 33 days after treatment and after 38 days they were completely yellow and ready for eating. Flavour, taste and colour were normal. Five of the 32 hands, on ripening, showed some black anthracnose spots on wounds made at harvesting. Eight hands were reserved in a small climatic chamber without ethylene: the first yellowing occurred after 38 days but the colour was an abnormal greyish shade and the pulp hard.

A third experiment was made on a larger quantity of fruit (Fig. 2) shipped in two metal containers, each of $8m^3$ from Farm no. 6/8, Morodi, Guiba. On May 7th, treatments were applied to the fruit at the farm. The experimental shipment consisted of 300 cardboard boxes in the following proportion:

First container:	75 boxes with untreated hands;
	75 boxes with K_3 treated hands;
Second container:	75 boxes with K_1 treated hands;
	75 boxes with K_3 treated hands.

Untreated fruits were placed in one container only because of the strong ripening stimulation effect of ripe bananas, caused by their ethylene production on other fruit during transport.

All experimental fruits were harvested from a single field and processed in the same packing centre. The control untreated bananas were wrapped in polyethylene and boxed after washing while the treated fruit were dipped in a K_3 water solution or in a K_1 emulsion after washing and before packing. The procedure of treatment with vitamin K_1 was as before; vitamin K_3 (2 methyl - 1, 4 naphthoquinone or menadione) is water soluble: the treatment consisted simply of dipping the fruit in a solution of 100 g of vitamin K_3 in 100 l of water, with 80 ml of a surface-active agent. The vitamin solution (K_3) and emulsion (K_1) were changed every two hours because vitamin K is water labile and slowly degraded, so that in solution they gradually lose their effect. Vitamin K_3-treated fruit were included in both containers because the use of this vitamin was the more important part of the experimental system, as the behaviour of the control and of the vitamin K_1-treated fruit were roughly predictable.

The containers were loaded and sealed at the farm, returned to port and shipped on deck on M/S Sloman Alsterpark, on 12th May 1969. The temperature in the containers at sealing was 44°C. The ship reached Naples on 29th May and the containers were opened the next day, i.e. after a journey of 19 days, 24 days from harvest and treatment. The boxes were immediately unloaded from the containers: internal temperatures were around 50-55°C. As the metal walls of the containers were exposed during transit to the tropical sun, internal temperatures had probably reached at least 60°C: this represents very extreme conditions for delicate fruit, like the banana. On opening the first container the control fruit were yellow-brown, overripe, rotten and of a liquified consistency, while the K_3 treated fruits were fully green, with only traces of rotting but with the pulp softened. The softness of the pulp was more apparent in hands in boxes placed near the container walls and less in those near the centre: this is evidently an effect of the heat from steel walls, when exposed to the sun.

The fruit in the second container were in better condition, with the K_1 treated hands all fully green, healthy and normal with clean crowns and fingers. The pulp of fruit from the middle of the stow was firm, that of fruit from near the wall, very slightly soft. The K_3 treated hands were very similar, except for a more marked softness of the pulp of the fruit in peripheral boxes.

After examination, the fruit in the first container was abandoned. The boxes from the second container were sent on May 31st to a banana dealer in Florence and were placed in a ripening room together with boxes from the refrigerated holds of the same ship. The dealer was asked to treat and to evaluate the experimental and the normal fruits in the same way. The result was that on 75 boxes with K_1 treated fruits, 35 (46.6%) were rejected for pulp softness, irregular maturation and crown rots, while 40 (53.4%) began to ripen on June 6th and were sold to consumers by June 9th of the 75 boxes with K_3 treated hands, 48 (64.0%) were rejected for the same defects and 27 (36.0%) were ripened and sold within the same period. Four further shipments were then made leaving to farmers of different technical levels the treatment of the fruits by their own means, according to detailed instructions. This gave some idea of the farmer's capacity to handle the new technique.

A shipment on M/S Mare Antartico (June 17th-July 6th) consisted of 85 cardboard boxes with K_3 treated fruits coming from two farms (nos. 5 and 22) loaded under refrigeration. The farmers chose the fruits at an advanced stage of ripening and with numerous wounds; the dipping time was 5 min but the solution was used for 4 hours instead of 2. The latex emerging from crowns was not completely removed by the pretreatment washing, with the result that on arrival at Naples, 10% of fruits were damaged by anthracnose: but none were yellowing.

A larger shipment of M/S Sloman Alsterpark (June 26th-July 15th) under refrigeration consisted of 5,500 boxes of K_3 treated fruits from 15 farms. All these farms harvested fruits at an advanced stage (3.5) but only 3 applied the treatment in a correct way (nos. 5, 6 and 21) while the others did not completely remove the latex and did not carefully observe dosage and dipping time. The 2,400 cardboard boxes shipped by the first 3 farms arrived in perfect condition while the remaining 3,100 showed 10% yellowing and 5% ripened fruits with frequent infections.

On the M/S Sloman Alstertor (July 2nd-22nd) 173 cardboard boxes were shipped under refrigeration by farm no. 15 (Marietti) after dipping the fruit in K_3 solution. The fruits of this shipment had previously been rejected for commercial exportation, half being over-full, and the other half because of yellowing. The dipping time was approximately observed but the vitamin solution was exposed to sunlight. On arrival in Naples 12% of the full fruits and 20% of the yellowing fruits were rejected.

In the final shipment, 13,103 cardboard boxes containing K_3 treated fruits were loaded in a compartment with a light refrigeration (16°C) on the M/S Mare Boreale that left Kisimaio on July 16th. Formerly this shipment was planned to be without refrigeration but the inability of a large number of farms to undertake the treatment in a satisfactory manner does not allow an experiment on such large quantities of fruits at present. This ship was in transit at the time of writing.

A large shipment of treated fruits in a non-refrigerated hold will probably be attempted shortly when we hope that every farm will achieve:

1. A complete removal of latex with a pretreatment washing in 1.3% aqueous calcium hypochlorite for 20 mins; taking care to keep the crowns submerged. The latex, in the presence of vitamin K_3, flocculates rapidly, degrading the vitamin solution;
2. A treatment in the shade, as sunlight degrades the vitamin.
3. A careful dosage of 1 g of vitamin K_3 per litre of water; after 1.5 hr. an extra 0.5 g per litre of vitamin must be added to extend the washing time to 3 hrs;
4. A dipping time for the fruit in the vitamin solution not less than 5 mins.

- A short drying period in the shade before packing.

The bigger and more modern centres of Genale and Giuba are to be modified to allow for the application of fungicide treatments, such as thiabendazole, or of inhibitors. During the periods of high incidence of anthracnose an association of TBZ and vitamin K is now considered to be the best solution while the vitamin alone is probably sufficient to control low levels of infection.

Under laboratory conditions the behaviour of pure cultures of *G. musarum* and *Fusarium* sp. in presence of vitamin K_1 and K_3 has been examined.

The first experiment involved submerging the pure cultures (4 replicates and 4 controls per species) 3 days after inoculation, when mycelium was just appearing at about 20°C, in an 0.1% aqueous emulsion of vitamin K_1 for 5 min. After exposure, the vitamin emulsion was recovered and measured: it was found that each 10 cm. Petri dish containing 30 ml of inoculated carrot agar, took up 0.3 mg of vitamin K_1. Fifteen days after treatment, delay of mycelium growth and of fructification, was observed with both fungi.

A second experiment was made, on the same pathogens, with 0.1% vitamin K_3 solution, on one day old cultures. The time of exposure was increased to 1 hr. in order to give a greater difference between treated and untreated replicates. After recovering the vitamin solution, 0.5 mg of vitamin K_3 remained in each Petri dish. Ten days after treatment, treated *Gloeosporium* cultures presented a marked floccose appearance of the mycelium and only rare fructification while the control cultures showed abundant fructification. Treated *Fusarium* cultures showed a delay in mycelium production and conidification.

A third experiment was made, on the same organisms by suspending the inoculum in 0.1% vitamin K_3 solution. The conidia remained in the solution for 5 min; then 2 ml of this inoculum was added to each Petri dish, so that the vitamin was diluted 15 times, giving a vitamin K_3 dosage of 0.2 mg per plate. A very substantial delay was observed in the initiation of growth: on the controls, mycelium appeared on the surface after 40 hrs but on treated dishes only after 68 hrs. After 3 days the difference between treated and control cultures was less evident and 10 days after treatment any differences almost disappeared; indeed, by that time 2 replicates of treated *Gloeosporium* cultures showed more vigorous growth than the controls. This suggests that the small dosage used is inhibitory only in the early stages of growth.

A spectrophotometric study on ripe K_1 treated bananas, on arrival in Italy showed the presence of the vitamin with a maximum absorption peak in the ultraviolet, at a wave-length of 2700 Å. The quantitative data on the residue were only approximate, suggesting a concentration of less than 2 ppm: more detailed studies on a large quantity of ripe treated fruits are needed. It is hoped that these will shortly be undertaken in co-operation with the Institute of Medical Hygiene of the University of Florence.

Future research programmes will involve studies on the action of vitamin K on spore germination, on pure cultures of fungi, on the respiratory metabolism of treated tissues and on vitamin lability under various conditions. Research on vitamin metabolites and of the mode of vitamin action on specific enzymes are under consideration, for the future.

We may now consider some possible mechanisms of action of vitamin K compounds.

Our hypothesis starts from the consideration of two different theoretical interpretations of energy transfer mechanisms.

The first, illustrated by Clayton (1963), Bishop (1966) and others assumes that in the chloroplasts several hundred chlorophyll molecules co-operate in harvesting the energy of the light quanta and delivering this energy to the photo-chemical reaction centre for the electron transfer events that lead to the utilization of chemical energy in metabolic processes. According to this theory the electron transfer chain is represented as a set of separate monomeric redox proteins which interact with each other selectively and sequentially. The chlorophyll molecules are disposed in layers of protein and lipids, with quinonoid molecules in a fairly constant proportion at intervals. These quinonoid compounds, which are directly implicated in the electron transfer system, include the plastoquinones, tocopherylquinones, ubiquinones (or coenzyme Q) and vitamin K.

These molecules are responsible for energy transfer and a delicate equilibrium between electron donors and acceptors must be maintained if energy transfers and consequent metabolic processes are to continue. Dipping the fruit in a vitamin K – rich solution alters this balance. It is considered that an electron absorption or trapping by excess of carriers, probably could reduce the charge to a level too low for a valid excitation. It is also important whether the various types of quinones are active in specific metabolic pathways or whether some or all of them are capable, when present in excess, of stopping the energy transfer at a variety of sites (Hilton, Jansen and Hull, 1963).

Green and Silman (1967) indicate a theory based on the existence of a set of four different complexes which collaborate sequentially in electron transfer. The transfer, catalyzed by special mobile molecules, entails a restricted mode of molecular collision. The transfer chain is thus the summation of a set of separate and separable complexes which contain 3 to 4 different redox proteins as well as protein and lipid. The mobile link is the ubiquinone or coenzyme Q, a fully substituted benzoquinone with a side chain of 6 to 10 isoprene units. This may be substituted in some bacterial species by a derivative of vitamin K.

According to this theory, the inhibiting action of the vitamins K could be better explained by a combination of their molecules with one or more complexes, suppressing any electron transfer by interruption of the chain. On this explanation it would not be a matter of trapping or absorption, as intended within the former theory, but a phenomenon of the same nature of that illustrated by Rieske (Green *et al,* 1967) for Antimycin A on various organisms.

Several workers have indicated that an excess of vitamin K_1 can stop the Hill reaction but no attempts have been made to investigate whether this phenomenon occur at

other metabolic levels, especially in pre-climacteric fruits. Our observations suggest that the inhibitory effect of vitamin K is a general one, when an excess is present and that various metabolic cycles, including the ethylene pathway are involved. Whether some metabolic pathways are more affected than others is not yet certain. As far as bananas are concerned it is evident that out of some thousand vitamin K-treated fruits shipped at very high temperatures none was yellowing on arrival: the inhibition of the Hill reaction cannot be responsible, as the fruit is kept in the dark during shipment. Also, when kept at temperatures between 20° and 30°C the pulp of vitamin K treated fruits remained firm; this suggests that a very complex process involving many enzyme systems can be affected. Whether vitamin K has an effect on enzyme efficiencies needs to be investigated in the light of the hypothesis that vitamins are closely related to enzymes (Hardin, 1961). There is also an effect of vitamin K on pure cultures of fungal pathogens of the banana fruit that has great significance as these fungi are incapable of photosynthetic activity: this suggests that the inhibitory effect of vitamin K is general. It is acting in a comparable manner on banana fruit and on its pathogens of different genera.

On the basis of the discussion of the post-harvest physiology of fruits given by Hansen (1966), the likelihood of a more or less general metabolic block being induced by vitamin K treatment, and involving ethylene production seems to be high.

Why is the effect of vitamin K reversible, so that after a certain period the ripening process can be restored? It is presumed that this could be explained by a gradual restoration of the balance within the system, brought about by the lability of vitamin K in water: the excess vitamin being slowly degraded.

Owing to this water lability of vitamin K, it is now considered that the solution in the dipping bath is only effective for about 1 to 1½ hr, even in the shade. A spectrophotometric investigation of the rate of degradation of vitamins K at known light intensities is now in hand.

The use of plastic wrapping is important, to ensure a low rate of metabolism in the fruits even when the inhibiting effect of the vitamin is decreasing.

In conclusion, it must be emphasized that a greater knowledge of the metabolic processes of fruit after harvest is necessary in order to obtain better quality products, and at the same time achieve a reduction of production and handling costs.

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Figure 1
Diagram of the ripening process of non treated and K_1 treated bananas when the dipping has been applied after a traditional refrigerated transport.
C = control fruits; T = vitamin K_1 treated fruits.

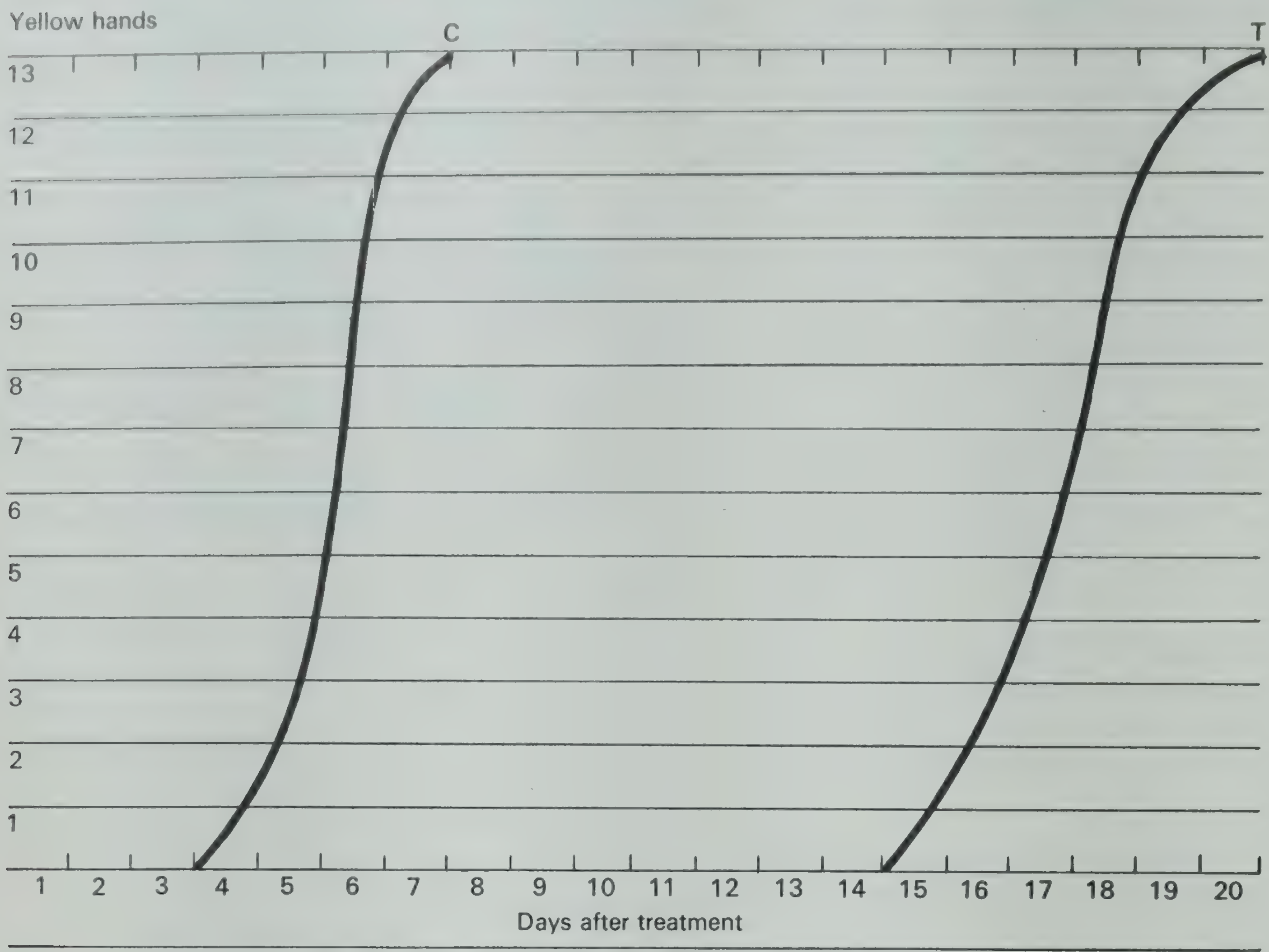
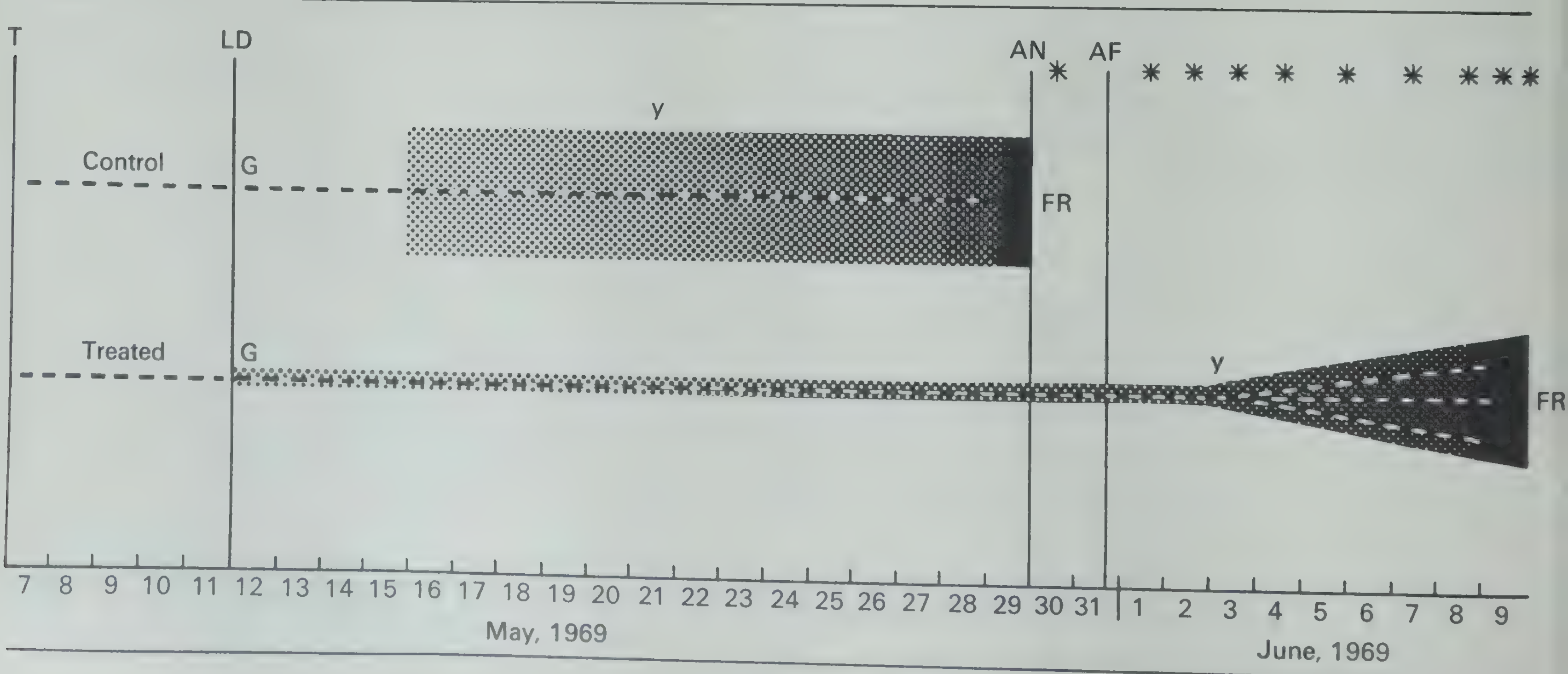


Figure 2
Diagram of the behaviour of bananas treated after harvest by dipping in 0.1% vitamin K and shipped from Somalia to Italy in metal containers placed on the ship's deck.
T = treatment date; LD = loading date; AN = day of arrival in Naples; AF = day of arrival in Florence;
G = green fruits; Y = yellowing fruits; FR = fruit full ripeness.



Discussion

M. Devinat: Would Dr. Hatton comment on the external appearance of grapefruit for marketing?

Dr. Hatton: Early grapefruit shows pitting quite easily at low temperatures: storage at 60°F is satisfactory; below this temperature, pitting occurs. Late grapefruit, which are normally of higher quality can be stored at 50°F without pitting. There are some other factors, too. Florida has a harsher climate but this does not affect internal quality. California has a different climate; the fruit has a beautiful external finish, but is not very juicy. By using carbon dioxide we get round the pitting problem at lower temperatures, and with the use of TBZ we think we will be able to control melanose.

Mr. Cutts: Two graphs shown during the reading of Dr. Chace's paper illustrated how the atmosphere was made up of oxygen and carbon dioxide at various levels. Was the rest nitrogen? If so, was it introduced by direct injection techniques or was the level of nitrogen obtained by scrubbing out the carbon dioxide?

Dr. Hatton: The remainder is nitrogen. We have cylinders which leak nitrogen into chamber. A chromatographic set-up records carbon dioxide and oxygen levels so we know what amounts of nitrogen are wanted. We are not using a constant flow system, and do have active volatiles to be accounted for. Later in the week I will give some background on avocado work which has been done in an open flow system.

Dr. Emilsson: Would you like to comment on the need of air renewal?

Dr. Hatton: We have made many shipping tests to Rotterdam under different conditions. We have come to the conclusion that it would be sufficient to ventilate the fruit for 15 minutes every day. Because of the way these fruits are stowed, often without proper ventilation, there is carbon dioxide build-up. I believe that if the fruit was pre-cooled and had more ventilation, there would be less carbon dioxide build-up and less trouble.

Mr. Goldenberg: I am surprised to see that Dr. Hatton uses conditions which contain a fair amount of carbon dioxide. I understood that good conditions for storing citrus involved exclusion of carbon dioxide. One should scrub it out and have plenty of fresh air to avoid physiological injury. He said that high carbon dioxide can cause off flavours.

Dr. Hatton: So far we have found 5% carbon dioxide and 15% oxygen more or less optimum, but we have not gone very far. Carbon dioxide has been a problem: a certain amount seems to be beneficial, and 5% seems acceptable. We are in a dilemma: if we lower oxygen or raise carbon dioxide we get off flavours. We have to have a compromise. Whether we will ever establish conditions for citrus as good as we have for apples, I do not know.

M. Laville: Qu'elle est l'action des vitamines K_1 et K_3 sur le developpement des pourritures survenant après blessure des fruits verts?

Prof. Beccari: On bananas treated in Somalia and transported to Italy, generally *Fusarium* rot has been greatly retarded. In the case of *Gloesporium,* mycelium developed on the larger wounds, but on small wounds both mycelium and conidiophore development has been retarded. There are differences in effect between the large and small wounds. *In vitro,* the fungistatic action is certainly greater on *Fusarium* than on *Gloeosporium.*

Dr. Emilsson: What is the approximate cost of the Vitamin K treatment?

Prof. Beccari: Vitamin K_1 is very expensive at 1.5 million lire/kg, but Vitamin K_3 is very cheap at £2.5/kg.

Dr. Haisman: What made you choose these vitamins K_1 and K_3?

Prof. Beccari: I was studying the effect of the light on banana ripening and found some inhibitory effects. I thought that if vitamin K would stop the Hill reaction it might stop other actions: This phenomenon has a connection with electron transport.

Dr. Samson: Some of Dr. Mapson's graphs suggest that results with 13% oxygen are better than with 10%. Do all concentrations of oxygen above 8% have similar effects?

Dr. Mapson: In dealing with bananas, I think any difference between results at 10% and 13% oxygen was merely experimental variation.

I would like to comment on the effect of Vitamin K. The enzymic synthesis of ethylene is inhibited by dihydroxyphenols, e.g. chlorogenic acid and catechol and also by certain quinones which react with sulphinic acids which are necessary co-enzymes. Ethylene synthesis appears to depend upon free radical formation and may be inhibited by compounds capable of trapping free radicals. It is possible that vitamin K might act in this way. If the fundamental respiration is completely blocked, the fruit passes into a condition where there is anaerobiosis, which results in physiological damage.

M. Deullin: Does Dr. Mapson agree with Burg and Burg who consider that the effect of ethylene on bananas depends on the degree of the ripeness: that partially ripened bananas are more sensitive to ethylene that those which are more developed?

Dr. Mapson: Yes.

M. Deullin: I understand that Prof. Beccari's experiments have been carried out with bananas picked in the month of March, but I think in Somalia the most difficult bananas to transport are those picked in May and June. Has he carried out experiments with these?

Prof. Beccari: We started the first shipment on the 26th February, the second on 11th May, the third in June and the last in July.

M. Deullin: It is most important to conduct experiments on bananas at the season when quality is worst.

Mr. Goldenberg: When you have added Vitamin K_1 or K_3, how do you get rid of them to allow ripening of fruit?

Prof. Beccari: The action of Vitamin K is not a lasting one, after a very limited period, it is destroyed and normal metabolism starts again.

Dr. Mapson: Prof. Beccari, have you measured the respiration of the tissue in the presence of Vitamin K? If you are inhibiting electron transport this should have a marked effect on total respiration of the tissue.

Prof. Beccari: This is now in hand. We shall measure the respiration of the different tissues of treated and untreated bananas. Other biochemical investigations are also in progress.

Dr. Mapson: It would be interesting also to see whether there is a response to ethylene or not.

Prof. Beccari: This is also a very important poin . I hope to find the needed collaboration for this work.

Senhor Mascarenhas: Could Vitamin K also be applied to pineapples?

Prof. Beccari: The application of this treatment to fruits other than bananas is a problem into which we have not yet looked. The action on fungi is not great, and is fungistatic rather than fungicidal. The main effect of the treatment is on the physiology of the fruit, not on the fungi.

Mr. Evans: During the investigations to test the effects of Vitamin K_1 and K_3 on cultures of *Gloesosporium* and *Fusarium*, Professor Beccari observed a delay in conidification and in vegetative development of the mycelium. Could Prof. Beccari give us details of the basal medium, incubation, temperature; pH of the medium; Dry weight results, etc.?

Prof. Beccari: The *in vitro* experiments were made using various techniques. Incubation temperature was 20°C, and the cultures were made on carrot agar medium, with a pH of about 5.6. In the first trial, the culture was immersed for five minutes in the test solution – i.e. the same time as the bananas were dipped, in the course of the practical trials. In a second series, the cultures were immersed for an hour. Further experiments involved suspending the inoculum, for the preparation of cultures, in a solution of vitamin K instead of sterile water.

In all experiments, very positive reduction of growth rate was observed.

Fourth Session

Tuesday 16th September
Afternoon

Chairman
Dr. E. C. Bate-Smith
Formerly Director,
Low Temperature Research Station,
Cambridge.

Low temperature injury in tropical fruit

J.C. Fidler
East Malling Research Station, Maidstone, Kent, England
and D.G. Coursey
Tropical Products Institute, London, England

Summary

The phenomenon of low temperature injury (otherwise 'chilling damage', 'low temperature breakdown' or 'LTB') is comparatively little understood. This phenomenon is entirely distinct from freezing damage, as it occurs in tissues exposed to temperatures near, but above, their freezing point: in some cases, damage may be observed at temperatures as high as 14°C.

Although observed in a number of temperate fruits, such as apples, pears and plums, the effect is most noticeable in plant materials of tropical origin. The sophisticated transport systems developed for the banana industry are designed around the maintenance of the temperatures required to avoid low temperature injury, but related phenomena in other tropical fruit materials have received little attention.

The present paper surveys the information available on the incidence of low temperature injury in tropical fruit materials. It also discusses what little is known of the biochemical and plant physiological processes involved, although most of the information available is derived from the study of temperate fruit produce. The phenomena observed appear to fall, in general, into two classes. Firstly, comparatively minor lesions which affect only a proportion of the individual fruit subjected to low temperature storage conditions: and secondly, more fundamental breakdown processes that affect all the fruit exposed to the low temperature and cause major disruption of the metabolic processes.

Introduction

Almost every newcomer to the tropics is advised that dire consequences will result from keeping bananas in a refrigerator, although the exact nature of these consequences is usually left unspecified. Such deterioration, usually known as 'Low Temperature Injury', 'Low Temperature Breakdown', 'LTB' or 'Chilling Damage' is more widespread than is commonly realized among materials of vegetable origin. It is especially common among tropical plant materials, as perhaps is not surprising as the phenomen is linked with the question of hardiness of plants (Levitt, 1956), but it also occurs in some temperate fruit and vegetable materials. This injury is essentially different from freezing damage: it occurs at temperatures which, although low, are definitely above freezing. The whole subject has been much neglected by research workers, and most of the available literature is descriptive. Only one major review of the subject exists (Fidler, 1968).

This is surprising, in view of the economic consequences of low temperature injury. For many fruit, reduction of temperature is the best practical method of extending storage life, but with many tropical fruits, the situation exists that they can be kept best at temperatures well above their freezing point, their storage life being reduced at lower temperatures by chilling injury, and at higher temperatures by increased metabolic activity.

This often results in the marketing period being short, or necessitates the use of more sophisticated and expensive storage methods than simple refrigeration. Wastage as a result of low temperature injury may also occur when tropical produce is stored or exposed for sale at low ambient temperatures – for example, during the English winter.

The symptoms of low temperature injury may take any of several forms. In avocados and bananas, discolouration of the vascular bundles occur. In the avocado the bundles lie in the pulp surrounding the stone and in the banana, browning of the bundles in the skin gives the fruit a dull colour. In the ripening room these fruit develop a dull, khaki colour, starch hydrolysis is slowed down, and the central placenta fails to soften.

Mangoes, papaya, and several other tropical or subtropical fruits, develop sunken spots on the skin. These types of injury are usually entirely physiological, no micro-organisms are involved, although fungal attack may subsequently occur, following the primary injury.

Injuries to citrus fruits vary between species. Oranges develop small brown spots on the skin; sometimes, a collapse of the oilcells leading to a condition known as 'gooseflesh' takes place. Grapefruit develop brown areas, some 2 to 10 mm. diameter surrounded by a halo of small spots. Lemons usually show no external symptoms, but the internal membranes turn brown.

Causes of low temperature injury

Obviously, the primary factor in the causation of low temperature injury is exposure of the material to low temperatures: but other factors are also operative. We may initially consider temperature in isolation. If a particular cultivar or species of fruit is susceptible to injury, a more or less definite minimum temperature exists below which injury occurs; storage just above this critical value normally gives maximum storage life.

The critical temperature may be quite high, the highest recorded being 14.4°C. for the Lacatan banana (Furlong, 1962); for another common commercial variety of banana, Gros Michel, it is 11.6°C. This critical temperature may be defined very precisely at least for bananas to within 0.2°C, but with other types of produce there is more variation (Biale, 1960; Wardlaw, 1937a; Fidler and Nash-Wortham, 1961; Fidler, 1968). For many tropical or subtropical fruits, the chilling temperature lies between 8° and 12°C. With temperate fruit, such as apples, injury is only caused at lower temperatures below 3° to 4°C (Kidd and West, 1925; Plagge and Maney, 1924; Carne, 1948).

The degree to which injury occurs is conditioned not only by the temperature to which the fruit is exposed, but also by the duration of exposure. This has given rise to differences between figures published for the critical chilling temperatures for given tissues by different workers: some investigators either did not continue their experiments for a sufficient period, or did not examine the produce after return to ambient temperatures which would simulate normal marketing conditions.

Low temperature injury is associated with disturbances to the fruit metabolism, and it appears that there can be a primary, latent injury, most severe at lower temperatures, and a secondary, visible effect which develops more rapidly at intermediate temperatures. It is therefore possible, if samples are examined too early in the experiment, to conclude that damage does not occur at a temperature below the true critical value, or even to reach the anomalous conclusion that injury is more serious at intermediate than at lower temperatures.

This effect is clearly demonstrated by work on skin pitting of grapefruit (van der Plank and Davies, 1937). The fruits were stored at various temperatures between -0.5° and 10°C. and examined after progressive time intervals. No damage occurred at 10°C. After 25 days, there was no damage at -0.5°C. while the sample at + 7.5°C. showed the most severe pitting; after 52 days, the highest proportion of injured fruits was found at -0.5°C.

Similar relationships have been found for soft scald of apples, which may appear more quickly at 3.5° than at 0°C. although after about 40 days storage more injury occurs at the lower temperature (Tomkins, 1965). South African peaches and plums, exported to Europe, are kept under refrigeration for 16 to 20 days, to retard ripening. It has been shown (Davies, Boyes and de Villiers, 1936) that although they are ultimately more severely damaged at 0°C, the maximum damage in this period of storage occurs at 3.5° to 4°C.

In any study of a chilling damage situation, it is necessary to follow the produce through the normal marketing channels. Again to consider a temperate fruit material, Barker (1930) quotes the case of a shipment of apples from New Zealand, some of which had been carried at 5°C and some at around 0° to 1°C. On discharge, no injury was observable, but after storage at ambient temperatures, 12% of the fruit from the cold position had suffered injury, but none from the warm position.

With bananas, Wardlaw and McGuire (1931) found that Gros Michel developed chilling injury in 14 days at 11.1°C. and in only 9 days at 10.5°C. while Furlong (1962) working on Jamaican Lacatan bananas, obtained symptoms of chilling in 6 days at 12.2°C. and 10 days at 13.3°C: no injury was observable after 16 days at 14.4°C.

Even within a particular cultivar, susceptibility to low temperature injury may vary with degree of ripeness, or with mineral or carbohydrate content and thus may be influenced by cultural or climatic factors. Furlong (1962) has shown that both Lacatan and Gros Michel bananas are most liable to low temperature injury at the very stage at which they are normally cut from the stems and distributed to the retail trade. In this stage of maturity Lacatan bananas are injured in 2 hours at 1.1°C., 4 hours at 7.2°C. and 36 hours at 10°C., whereas they could tolerate exposure to such temperatures for much longer periods either green or fully ripe. Thus, bananas are distributed, and exposed to winter temperatures, at exactly the metabolic state at which they are most liable to suffer loss of quality. This stage of maturity has been shown (Gane, 1936) to correspond to the peak of the respiratory climacteric. No data are available on the effect of mineral nutritional status with tropical fruit, but it has been shown with apples that conditions which give rise to high potassium, magnesium, and phosphorus contents, favour resistance to low temperature injury (Wilkinson, 1959–1965). Climate also has a profound influence on the ability of fruit to withstand low temperatures. For example, Cox's Orange apples grown in mainland Australia may be stored at 1.5°C., while the minimum temperatures for this variety grown elsewhere are: Tasmania, 2°; New Zealand 2.5° to 3°; UK 3° to 4°C. Similar considerations doubtless apply to many tropical fruit.

The inability of most English apples to withstand low temperatures has led to the use of controlled atmosphere

(CA) storage, in which atmospheric composition as well as the temperature is controlled. In CA storage, a concentration of 5 to 10% of CO_2 is maintained, and additionally or alternatively the concentration of oxygen is reduced to about 3%. It was found (Kidd and West, 1925) that apples were more susceptible to low temperature injury in CA storage than in air, and that the temperature for CA storage should be about 1°C higher for air. Nevertheless, the use of CA storage results in a considerable increase in storage life. Gane *et al* (1953), in experiments on CA storage of bananas, obtained evidence that the presence of CO_2 in the atmosphere increased the damage from chilling. Tomkins (1963; 1966) obtained similar results with tomatoes. Nevertheless the application of CO_2 in suitable concentrations can effectively reduce the incidence of low temperature injury.

Many physiological injuries to plant tissue during storage are influenced by the rate of water loss. In the present context, it has been stated that wrapping grapefruit in waxed paper, to reduce transpiration losses, results in a reduction of the critical chilling temperature by 3°C. (van der Plank and Davies, 1937).

The reverse relationship may also apply and reduction of water loss result in increased injury. Conditions which restrict water loss from tomatoes result in increased wastage (Tomkins 1963; 1966). This is not so much a direct effect on low temperature injury, but rather an increased liability to invasion by fungi under more humid conditions. Similar results have been obtained for apples.

Control of low temperature injury

So little work has been done on low temperature injury in tropical fruit, that most of the discussion in this and the next section has to be based on material published on temperate fruits. Fairly low concentrations of CO_2 in the atmosphere increase liability to injury, while exposure of apples to high concentrations of CO_2 for brief periods can be used to reduce susceptibility to a level which enables storage at lower temperatures. For example Gerhardt and Ezell (1933) controlled soft scald in apples by exposing them to 35% CO_2 in air for a day, prior to storage at 0°C. while Brooks and Harley (1934) successfully used the same concentration for 3 days before refrigerated storage.

More recently it has been shown that exposure to 20% CO_2 during a period at 15.5°C. part way through storage at 0°C. largely eliminates low temperature breakdown in some varieties of apple. (Smith, 1958). Warming alone, without CO_2 treatment can also lead to a reduction of injury. Control of internal browning of Victoria plums, stored at -0.5°C. has been achieved by warming them to 18.5°C. for two days, at about the 15th to 20th day of storage (Smith, 1947a; 1947b).

South African stone fruits were formerly shipped to Europe at 0°C. and internal browning was not serious at this temperature. However, exposure to low winter temperatures after arrival can cause failure to ripen and internal browning. Ripening the fruit on arrival, at 18° to 20°C. overcame this, and resulted in minimal damage (Barker and Furlong, 1937).

The 'dual temperature' method of overcoming low temperature injury (Smith, 1950) was introduced subsequently. The fruit is cooled rapidly to -0.5°C. (in the case of plums) as soon as possible after harvest, and are carried on board ship at this temperature for about 4 to 5 days, after which the temperature is raised to about 8°C for the rest of the voyage. This system has proved quite useful and the experience obtained may be a guide for those concerned with the export of chill-sensitive tropical fruit. It indicates that the problem of low temperature injury is not confined to the transit conditions, but is also relevant – at least in winter – to storage in the importing country. This indicates the need for the appreciation of this problem, not only in the producer countries, but also among traders in the UK and elsewhere.

Physiology and biochemistry of low temperature injury

It was noted by Kidd and West (1926) that the respiration rate of chill-sensitive apples increased when stored at 1°C. as soon as breakdown began. More recently, Fidler and North (1967) have recorded increased rates of CO_2 production and of oxygen uptake in apples, before the visual appearance of low temperature breakdown. The rate of production of CO_2 by Cox's Orange apples, after 77 days in air at 0°C, was as high as that of fruit which had been continuously at 3.5°C. but there was no appearance of LTB until the 89th day. When the apples were stored in low concentrations of oxygen (2 to 5%) in the presence of 5% CO_2, the rate of respiration at the chilling temperatures (0° and 1.3°C.) was more rapid than in air. When low temperature breakdown had developed extensively, the respiration declined. A similar relationship between respiration and exposure to chilling temperatures has been observed for some of the cucurbits, (Eaks and Morris, 1956).

More recently, Fidler and North (1968) have stored Cox's Orange apples at 0° and 3.5°C. When apples were transferred to 18.5°C. for 3 days after 52 days at 0°C. and then returned to 0°C, the rise in respiration was reversed; afterwards it again rose, but the rise could again be reversed by warming, after the 85th day. If transferred to 3.5°C. after warming at the 52nd day, the rate of respiration was the same as that of the sample which had been continuously at 3.5°C. but if the warming treatment was omitted, the rate at 3.5°C. was considerably higher. It is noteworthy that all the samples at 3.5°C. had the same RQ of 1.4–1.5 and that all the samples stored at 0°C. had a higher RQ, between 1.5–1.7.

Biale (1960) indicates that the lowest temperature at which a climacteric rise could be observed in Fuerte avocados was 7.5°C. and that the climacteric was suppressed at 5°C. which coincides with the chilling temperatures for this variety.

It has also been observed that CO_2 production by papaya fruits was higher than expected, at chilling

temperatures, (Jones, 1942). It has been suggested (Nelson, 1926) that injuries similar to low temperature pitting, can be induced in some vegetables, by storage in low concentrations of oxygen, indicating the low temperature injury is due to inability to obtain sufficient oxygen. If this is correct the occurrence of low temperature injury should lead to a rise in RQ and oxygen consumption should fall.

Little work has been done on the analysis of normal tissues and those injured by low temperature. Leonard and Barnell (1934) and Barnell (1941) found that the rate of hydrolysis of starch was considerably slower in bananas with chilling symptoms than in uninjured fruit, which may, of course, be regarded as part of an inhibited ripening process. Scurti and Pavarino (1934) also working on bananas, noted that the tannin content of the peel of chilled fruit remained high. Sucrose hydrolysis in papaya was slowed down in injured fruits (Jones, 1942).

In sound apples at constant temperature, the concentration of malic acid falls logarithmically with time, but the incidence of low temperature breakdown is accompanied by an increase in the rate of loss of acid (Haynes, 1925). This has recently been confirmed by Fidler and North (1967); with Cox's Orange apples stored at 0°C. once low temperature breakdown commenced, the rate of loss of acid was doubled. There was little change in respiratory quotient.

Hulme, Jones and Wooltorton (1961) and Hulme, Smith and Wooltorton (1964) have found that in apples there is an increase in oxaloacetic acid and a fall in α-oxoglutarate and pyruvate, before any visible signs of low temperature injury. If the apples are then subjected to higher temperatures the α-oxaloacetate concentration falls. It was suggested that there was interference with the normal functioning of the Krebs cycle enzymes, although Wills and McGlasson, (1968) have shown, by storing apples under conditions which affected both the rate of loss of water and the severity of breakdown (at -1°C.), that these differences were not associated with different rates of accumulation of the keto-acids.

Chilling has been reported as being associated with a fall in ascorbic acid content of pineapples (Miller and Heilman, 1952) and bananas (Harris and Poland, 1939) but not tomatoes (Craft and Heinze, 1954).

Fidler and North (1968) have observed increased concentrations of sorbitol in apples stored at low temperatures; the concentration correlates well with incidence of LTB, but the authors stress that this may not necessarily indicate that there is a direct connection.

Low temperature injury must arise as the result of some form of interference with the normal metabolic processes of the tissues; and some of the biochemical changes have already been mentioned. When fruits are raised to higher temperatures for brief periods, provided no irreparable damage has already been done, the metabolic balance can be restored (Smith 1947a; 1947b; 1950). The imbalance might be due either to the effect of temperature on the relative velocities of the several intermediate stages of a pathway system allowing the accumulation of some intermediate normally present only in traces or to the intervention of a chain of reactions which does not occur above the critical temperature.

In the first hypothesis, the velocity of the reaction leading to the accumulation of intermediates must be affected by change of temperature less than that of the reaction in which it is metabolized. If this is the case, raising the fruit to a temperature above the injury limit leads to disappearance of the intermediate. Presumably some critical concentration, below which injury is slight or absent, exists; if this concentration is exceeded, then raising the fruit to a higher temperature will not prevent injury, and indeed, many accelerate the appearance of visible symptoms. Thus when apples were warmed after six weeks storage at 0°C. maximum control of low temperature breakdown was achieved: samples which warmed only after eight or more weeks at 0°C. showed progressively more severe injury (Smith, 1947a; 1947b).

The theory of temperature-dependent 'toxin' was discussed mathematically, by Plank (1941). The assumption was made that the metabolite was volatile, and that the rate of loss accelerated by rise in temperature. The production of ethylene and other volatiles by apples is not, however, influenced by the presence of CO_2 (Smith, 1962). The basic concepts inherent in Plank's treatment do, nevertheless, apply to a non-volatile metabolite. Support for the theory has recently come from the work of Pantastico (1968) who showed that there is a build-up of acetaldehyde in chilled grapefruit: this substance, applied to grapefruit, can cause skin disorders similar to chilling. Changes in the volatiles of apples in which chilling injury has occurred have recently been reported (Wills and Scott, 1968; Wills and McGlasson, 1969).

Both these hypotheses and others not yet formulated may well be correct for different types of produce and the basic causative factors vary from one material to another. The variation in the symptoms of injury and in the length of time needed to produce them, suggest that different mechanisms may be responsible in different cases. There seem to be two main types of low temperature injury. Firstly – we may take grapefruit or most temperate fruit as examples – the injury is severe, but occurs only in a percentage of the fruits; the lower the temperature the more fruits are affected. The intermediate metabolite theory could explain this type of injury, if it is assumed that there is a variation in susceptibility between individual fruits, dependent on variation in composition.

Secondly, in most tropical fruit, such as bananas, all the fruits are affected when they are stored below critical temperature, which is usually in the range 8°C. to 12°C. As has already been indicated the critical temperature for a given variety of fruit may be very sharply defined. This suggests that the initial damage may be physical and the disturbance to the metabolism consequent on the physical change. The change might be one of viscosity, or in the permeability of a cellular or mitochondrial membrane.

It has long been known (Sachs, 1882) that cessation of cytoplasmic streaming occurs in some plant cells at temperatures as high as 11°C; in cells of hardy plants which are not subject to injury, streaming continues

even at 0°C. These observations suggest that damage may be associated with failure of the energy-producing mechanism (Lewis, 1956). This view is supported by the studies of Lewis and Workman (1964) on tomatoes: they found that there was a decline in phosphorylative ability with the onset of chilling injury, although in a later paper (Lewis and Martin, 1965) it was suggested that some of these observations need to be treated with reserve. However, a reduction in the P/O ratio of mitochondria from grapefruit has also been found when the fruit is chilled (Pantastico, 1968).

Changes in permeability of chilled tissue have been studied by Lewis and Workman (1964) in tomato and cabbage, at 0°C. at which temperature the tomato is injured, but the cabbage remains sound. It was found that electrolyte leakage from the tomato increased rapidly, but that the rate was constant in the case of cabbage. Similar observations on changes in membrane permeability have been made in root crops where there appear to be changes in the lipid composition of the membrane, when chilling occurs. It has been noted (Lyons, Wheaton and Pratt, 1964) that there are systematic differences in the nature of the cell membranes between chill-sensitive and chill-resistant plant tissues.

Golovkin and Tsvetkov (1966) have found, by electrical impedance measurements, that the permeability of apple membranes is reduced by storage at low temperatures; these electrical changes may be associated with chilling. No such work has yet been undertaken on tropical fruit.

The following table indicates some of the symptoms of chilling injury, and the temperatures at which they occur, for the more important tropical fruit, together with references to the main publications on the subject.

Fruit	Chilling Temperatures	Symptoms of low temperature injury	Principal References
Avocado *Persea americana* Mill.	0°–10° (according to variety)	Brown discolouration and softening. Development of 'off' flavour.	Harold, 1931; Wardlaw, 1937b; Lynch and Stahl, 1939; Biale, 1942; Mustard, 1952; Boyes, 1953; Campbell and Hatton, 1959; Pennock, 1959; Hatton and Reeder, 1965.
Bananas *Musa* spp. and cvs.	10°C–14°C	Failure to ripen. Building up of tannins, causing khaki discolouration of skin. Inhibition of starch/sugar conversion. Decline in ascorbic acid content.	Wardlaw and McGuire, 1931; Gane, 1936; Harris and Poland, 1939; Wardlaw, Leonard and Barnell, 1939; Barnell, 1940, 1941; Leonard and Wardlaw, 1941; Barnell, 1943; Barnell and Barnell, 1945; Gane, 1952; Biale, 1960; Furlong 1962; Pantastico, Grierson and Soule, 1967; Abilay, 1968.
Citrus Fruit *Citrus aurantifolia* Swing. *C. limon* Burm. *C. paradisi* Macf. *C. sinensis* Osbeck.	0°C.–10°C. (according to species and variety).	Pitting and spotting of the skin. Watery break-down. Discolouration of membranes.	Hawkins, 1921; Camp, Gaddum and Stahl, 1933; Wardlaw, 1933; Anon, 1935; Brooks and McColloch, 1936, 1937; van der Plank and Davies, 1937; Tomkins and Dreyer 1937; Hall, 1938; van der Plank and others, 1938; Miller and Schomer 1938; Wardlaw and Leonard, 1939; Tindale, 1945; Miller, 1946; Eaks, 1955, 1960; Pantastico, 1968.
Lychees *Litchi chinensis* Sonn.	ca 2°C.	Dulling of skin colours	Hatton, Reeder and Kaufman, 1966
Mango *Mangifera indica* L.	8°–10°C.	Skin blemishes Failure to ripen, lack of sweetness	Bannerjee, Kermarkar and Row, 1934; Wardlaw and Leonard, 1936; Cheema, Karmarkar and Joshi, 1939; Vickers, 1964;
Papaya *Carica papaya* L.	10°C.	Failure to ripen	Jones, 1942
Passion Fruit *Passiflora edulis* Sims.	10°C.	Red discolouration of skin Enhanced liability to mould attack	Anon, 1934; Anon, 1967
Pineapple *Ananas comosus* L.	8°C.–10°C.	Brown discolouration of the flesh. Waterlogging. Decline in ascorbic acid content	Williams, 1933; Miller, 1951; Miller and Heilman, 1952; Ginsburg, 1953; Akamine, 1963.
Sweep sop *Annona squamosa L.*	11°C.	Brown or blackish discolouration	Smith, 1936

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Biochemical aspects of ripening and chilling injury in mango fruit

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Summary

The climacteric rise in mangoes is marked by a considerable increase in the activity of the enzymes catalase, peroxidase and amylase, coincident with the decrease of the inhibitors of these enzymes present in the preclimacteric fruit. Ripening of the fruit is initiated by the inactivation of these enzyme inhibitors by ethylene and studies have been made on the effect of ethylene on the partially purified inhibitors.

Occurrence of chilling injury between 0°C - 5°C limits the possibilities of prolonging the storage of mangoes at these temperatures. In chilling injury there is a significant decrease in the soluble sugar content, (mainly sucrose), whereas there was no significant change in total hexose content, less starch break down and ascorbic acid accumulation. In addition to these changes there is accumulation of minerals in the injured part. Solubilization of insoluble pectins by increased pectinesterase activity seems to be one of the reasons of the development of softness during chilling injury. During this stage, invertase activity increases whereas that of amylase decreases as compared to the healthy tissue of the same fruit. K^+ ions activate invertase but inhibit fruit amylase considerably. Low concentrations of Ca^{++} ions favour activation of invertase but inhibit amylase. Mg^{++} ions and Na^+ ions do not show any significant effect on these enzyme activities.

Introduction

During the past decade considerable attention has been focussed on understanding the mechanism of the sudden rise of respiration at the climacteric in fruits (Hulme, Jones and Wooltorton, 1953; Hulme Rhodes and Wooltorton, 1967; Jones, Hulme and Wooltorton, 1965; Lance, Hobson, Young and Biale, 1967; Rowan, Pratt and Robertson, 1958; Tager and Biale, 1957). The climacteric rise in mangoes is marked by an appreciable increase in the activity of the enzymes catalase, peroxidase and amylase with concomitant decreases in the inhibitors of these enzymes present in the preclimacteric fruit (Mattoo, Modi and Reddy, 1968). Ripening of the mango fruit is initiated by the inactivation of these enzyme inhibitors by ethylene (Mattoo and Modi, 1969), and the present study has been made with regard to the effect of ethylene on the partially purified inhibitors.

Fruits respond differently to varying storage and ripening temperatures with respect to the rates of respiration and of ripening. Many fruits and vegetables are injured physiologically by low storage temperatures even when above the freezing point of the tissues. This low temperature injury is manifested in several ways, such as the appearance of skin blemishes, failure of normal ripening, and lack of flavour after removal from the cold storage (Fidler and Coursey, 1969; Lieberman, Craft, Audia and Wilcox,1958; Jones, 1942; Smith, 1950). Storage of mangoes at or below 5°C has been found to result in chilling injury (Akamine, 1963; Campbell, 1960; Cheema and Gandhi, 1926; Kinman, 1968). An attempt has been made to study some chemical and biochemical changes taking place in the mangoes during the development of chilling injury.

Materials and Methods

Mangoes (*Mangifera indica* L. ev Alfonso) obtained from the Bulsar district of Gujarat State, India were used. Bananas were obtained from a local market. The various stages of the fruit during ripening were marked by the colour development and appearance: (a) Unripe – hard green peel, white pulp and sour; (b) Partly ripe – slightly soft, green to yellow peel, yellow pulp and acidic; and (c) Ripe – soft, golden yellow peel and pulp, and sweet.

For the studies on chilling injury, the mangoes were exposed at 3°C till injury developed in some parts. Chilling injury was marked by softness and darkening of the tissue, and lack of flavour after removal from cold storage. The injured and the non-injured parts of the same fruit were cut into slices and used for the chemical and biochemical analyses.

The partial purification of the inhibitors from unripe (preclimacteric) mangoes was achieved by the procedure described previously (Mattoo *et al*, 1968). The same method was applied for purifying catalase inhibitor from unripe banana, with slight modification in that the supernatant obtained after magnesium acetate treatment was first precipitated between 0.1 - 0.6 saturation of ammonium sulphate, and subsequently aluminia Cγgel adsorption and elution were carried out. The gel eluates were dialysed and used as the partially purified inhibitory fractions. About 19 fold and 21 fold purified inhibitory fractions were obtained from mango and banana, respectively.

Ethylene was passed through the inhibitor solutions under airtight conditions, so as to maintain the appropriate concentration of 100 to 150 ppm, at a temperature between 0° - 3°C. The gas was bubbled through a capillary at the rate of 20 bubbles per minute till the required concentration was attained, and then the solution was analysed for its inhibitory activity. In controls a stream of air was passed under similar conditions.

The methods employed for analysis of sugars, total acidity and total nitrogen were as described earlier (Modi and Reddy, 1967). Sucrose was the main disaccharide, and citric acid the major acid identified: these have been estimated previously (Modi and Reddy, 1967).

For analysis of ascorbic acid, 30 gm of mango pulp was extracted in 5 per cent metaphosphoric acid. Ascorbic acid in the filtrate was estimated by the modified colorimetric method of Roe and Kuether (Hawk, Oser and Summerson, 1954).

To estimate starch, mango pulp was ground with absolute alcohol till the residue was white and powdery, and this was centrifuged. The residue was suspended in 0.02 M phosphate buffer (pH 6.8) and digested with α-amylase at 37°C overnight. The enzymatically hydrolysed solution was further hydrolysed with boiling 0.1 N HCl for 2 hr, neutralized with anhydrous sodium carbonate, and free sugar estimated by Cole's method. The free sugar values obtained were calculated in terms of starch.

For free mineral content, the fruit pulp was extracted in double glass distilled water, filtered and the filtrate was analysed. For the total mineral content the pulp was ashed in a muffle furnace and the ash dissolved quantitatively in acidified water. K^+, Na^+ and Ca^{++} were estimated using a flame photometer. The procedures were standardized by using reference solutions of Analar grade salts of these minerals.

Methods employed for the preparation of cell free extracts, for estimation of catalase and peroxidase activities were essentially those reported earlier (Mattoo *et al*, 1968). Cell free extracts for the assay of pectinesterase were prepared in 10% NaCl as recommended by Kertesz (1955). Protein in the TCA precipitates of cell free extracts was estimated by the method of Lowry *et al* (1951).

Amylase activity was determined by the method of Bernfeld (1955). The reaction system contained 0.5 ml of 1% starch, 25 μ moles of tris-maleate (pH 7.0) and an appropriate concentration of the enzyme extract (230 - 650 μg protein), in a final volume of 1.5 ml. Incubation was carried out at 37°C for 30 min. Blank tubes contained boiled enzyme. Reducing groups liberated from starch were measured by the reduction of 3,5-dinitro-salicylic acid.

Invertase activity was determined by measuring hexose formed by the method of Nelson (Ashwell, 1955). The reaction mixture contained per 2 ml: 100 micromoles of sodium acetate buffer (pH 5.0); 25 micromoles of sucrose and an appropriate concentration of the enzyme extract (50 - 300 μg protein). Blank tubes contained boiled enzyme. Incubation was carried out at 37°C for 1 hr. and the reaction stopped by adding 3.0 ml of 0.5M dibasic sodium phosphate and heating in a boiling water bath for 2 min. Precipitated protein was filtered off and various aliquots of the filtrate were analysed for the reducing sugars obtained.

Pectinesterase was determined by following essentially the method of Kertesz (1955) using the same assay system.

One unit of catalase is defined as that amount of enzyme which decomposes 1 micromole of hydrogen peroxide per hr. at 0°C and 1 unit of peroxidase is that amount of the enzyme which decomposes 1 micromole of hydrogen peroxide per min. at 25°C. A unit of amylase activity is that amount which liberates 1 mg of reducing groups calculated as maltose per 30 min. under the assay conditions. A unit of invertase activity is that amount which liberates 1 micromole of reducing hexose per hr. at 37°C. A unit of pectinesterase activity is that amount which removes 1 micromole of methoxy groups per min. at 25°C.

Results and Discussion

The effect of ethylene on the partially purified inhibitors of the oxidative enzymes, catalase and peroxidase, is shown in the tables 1 and 2. From the results in Table 1 it is evident that ethylene inactivates the catalase inhibitor with the result that the enzyme inhibition is reversed. Ethylene treatment, however, does not appear to affect the catalase activity of the test controls. Similar effects of ethylene on the reversal of peroxidase inhibition is evident from Table 2. These results support earlier observations (Mattoo and Modi, 1969) with mango slices on the stimulation of these enzyme activities, due to the inactivation of their respective inhibitors.

Further investigations showed that unripe banana also contains a similar type of catalase inhibitor; this inhibitor being capable of inhibiting the catalase of both banana and mango. This inhibitor is also inactivated by ethylene (Table 3), suggesting that these enzymes and their inhibitors from both fruits have similar characteristics.

Table 1
Effect of ethylene treatment on the activity of partially purified catalase inhibitor from mango*

System	Residual catalase activity (Units)
Ripe mango extract (control)	31.4
Ripe mango extract (Ethylene treated)	29.0
Ripe + Inhibitor (40 μg)	20.1
Ripe + Inhibitor (60 μg)	15.0
Ripe + Inhibitor (40 μg) (Ethylene treated)	31.1
Ripe + Inhibitor (60 μg) (Ethylene treated)	31.6

* Results are an average of five determinations.

Table 2
Effect of ethylene on the mango peroxidase inhibitor*

System	Residual peroxidase activity (Units)
Ripe mango extract (control)	0.060
Ripe + Inhibitor (40 μg)	0.020
Ripe + Inhibitor (40 μg) (Ethylene treated)	0.054

* Results are an average of five determinations.

Table 3
Effect of ethylene on the banana catalase inhibitor

System	Residual catalase activity (Units)
Ripe banana extract (control)	30
Ripe + Inhibitor (100 μg)	16
Ripe + Inhibitor (100 μg) (Ethylene treated)	33

During chilling injury, it was found that there is a significant decrease in the soluble sugar content, mainly sucrose, whereas there was no significant change in total hexose content. There was less starch breakdown, and ascorbic acid accumulated (Table 4). Such a pattern of changes was observed in the injured tissue at all stages of ripening. In addition to these changes there is accumulation of minerals in the chill injured part (Table 5). In chilled tissue there are higher concentrations of calcium, potassium and sodium in both the free and the total forms, than in healthy tissue.

Table 5
Free and total K^+, Na^+ and Ca^{++} contents of mangoes in chill injured and healthy tissue*

Nature of the tissue	K^+ Total	K^+ Free	Na^+ Total	Na^+ Free	Ca^{++} Total	Ca^{++} Free
Chill-injured	432	278	34	19	12	10
Healthy	372	218	28	14	8	6

* Results expressed are in mg per 100g pulp, and are an average of five determinations.

Chilling injury results in the softening and darkening of the mango tissue. Softening is generally associated with the changes in pectin constituents of the fruit: for example pectin in the cell wall has been shown to decrease during the ripening of mangoes (Reddy, 1968). An attempt was made to determine the activity of the pectinesterase in the chill injured and healthy part of the fruit. As is shown in Table 6, the specific activity of this enzyme is increased one and a half times in the injured part. Solubilization of insoluble pectins by increased pectinesterase activity appears to be one of the reasons for the development of softness during chilling injury.

Further studies were carried out on the changes in the activities of enzymes, amylase and invertase, responsible for other metabolic changes. The results in Table 6 indicate a marked difference in the specific activities of these enzymes in chilled and healthy tissues of the same fruit. Amylase was found to decrease two to three fold whereas invertase increased by more than two fold in the injured tissue. These data indicate the causes of the changes that take place in the sucrose and starch contents during chilling injury (Table 4).

Table 4
Changes in the chemical constituents of chill injured and healthy tissues of mangoes at different ripening stages†

Stage of fruit	Condition of the tissue	Free hexose sugar*	Total soluble sugar*	Total nitrogen*	Starch	Ascorbic acid
Unripe	Chill-injured	1.6 ± 0.2	2.1 ± 1.0	0.12 ± 0.01	9.2	0.290
	Healthy	1.9 ± 0.4	3.2 ± 1.2	0.11 ± 0.01	6.0	0.250
Partly-ripe	Chill-injured	4.1 ± 0.3	10.8 ± 3.0	0.18 ± 0.04	Traces	0.112
	Healthy	4.9 ± 0.5	13.0 ± 3.8	0.16 ± 0.05	Traces	0.090
Ripe	Chill-injured	4.3 ± 1.0	11.2 ± 0.6	0.14 ± 0.02	Traces	0.188
	Healthy	4.3 ± 1.2	13.0 ± 0.4	0.16 ± 0.02	Traces	0.165

* Means ± SD
† Results are expressed in gm per 100 gm pulp on fresh weight basis.

Table 6
Pectinesterase, invertase and amylase in chill injured and healthy tissues of mangoes*

Condition of the tissue	Pectin-esterase activity		Invertase activity		Amylase activity	
	Unripe fruit	Ripe fruit	Unripe fruit	Ripe fruit	Unripe fruit	Ripe fruit
Units per mg protein						
Chill-injured	1.8 - 2.2	3.5 - 4.5	0.85 - 1.30	2.1 - 4.5	0.8 - 0.90	1.2 - 3.5
Healthy	0.8 - 1.0	2.0 - 2.6	0.36 - 0.85	1.6 - 2.0	1.15 - 2.40	3.6 - 5.0

* Results are a range of 10 determinations.

Table 7
Invertase and amylase in the extracts of chill injured and healthy tissue of mangoes stored at various temperatures*

Temperature and storage period of the extracts	Invertase activity		Amylase activity	
	Chill injured	Healthy	Chill injured	Healthy
Units per mg protein				
Initial	2.10	1.60	1.20	3.10
3°C, 12 hrs.	0.93	0.14	0.80	2.40
35°C, 12 hrs.	1.20	0.96	4.50	5.10
-10°C, 12 hrs.	0.40	0.16	4.68	3.47

* Results expressed are an average of three determinations.

Table 8
Effect of Ca^{++} and K^{+} on the activity of amylase and invertase of chill injured and healthy tissue of mangoes*

Minerals tested	Concentration used (μ moles)	Amylase activity				Invertase activity			
		Chill injured		Healthy		Chill injured		Healthy	
		Unripe	Ripe	Unripe	Ripe	Unripe	Ripe	Unripe	Ripe
Units per mg protein									
Nil	–	0.90	3.15	1.15	4.3	0.22	1.08	0.07	0.85
K^{+}	5	0.51	2.60	0.70	4.0	2.20	1.50	0.13	1.75
	10	0.00	2.10	0.74	3.8	2.20	1.60	0.16	1.83
Ca^{++}	5	0.34	2.85	1.00	2.7	0.34	1.18	0.10	0.60
	10	0.14	2.39	0.90	2.6	0.52	1.20	0.20	2.00

* Values expressed are an average of four determinations.

Attempts were made to investigate the factors that are responsible for the modification of enzyme activities at low temperatures. Initially crude cell free extracts of both the chill injured and the healthy tissue of the mango were incubated for 12 hrs. at 3°C, 35°C and -10°C, after assaying the initial enzyme activities. Enzyme activities were then measured at 37°C. The results of these experiments are listed in Table 7. At 3°C and -10°C invertase activity is lost considerably. However, the enzyme from the injured tissue is more stable at 3°C as compared to its counterpart in the healthy tissue. Amylase, on the other hand, shows considerable increase in its activity when stored at 35°C and -10°C, whereas storage at 3°C results in decrease in its activity. These data indicate the possibility that the key enzymes regulating carbohydrate metabolism also might be playing a role in the development of this abnormality.

Metallic ions are known to influence the enzyme reactions. It was, therefore, of interest to study the effects of minerals (Mg^{++}, Ca^{++}, K^{+}, and Na^{+}) on the activities of amylase and invertase of the injured and the healthy part. Results of such a study are recorded in Table 8. It can be seen that amylase activity is inhibited by K^{+} and Ca^{++}

whereas these minerals favour the activity of invertase. It was found that Mg^{2+} and Na^{+} do not have any marked effects.

The results in Table 5 indicated the accumulation of Ca^{++} and K^{+} in the injured tissue; this accumulation could result by the release of minerals from membranes; translocation from other parts; or both processes. Earlier Lieberman *et al* (1958) suggested that low temperature injury causes an impairment of cellular permeability resulting in the leakage of minerals. Our data suggests that in mangoes at low temperature the development of softness is preceded by the impairment of cellular permeability, which results in the imbalance of the concentrations of minerals such as Ca^{++} and K^{+}.

The change in the concentrations of these minerals non-specifically affect the enzyme activities which in turn results in certain metabolic abnormalities eventually resulting in the development of chilling injury.

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Les contaminations fongiques des bananes durant et apres recolte

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Résumé

Les multiples pourritures survenant aux bananes après leur récolte résultent de l'action conjointe de plusieurs facteurs distincts. On peut les diviser plus ou moins arbitrairement en trois groupes, restant entendu par ailleurs que les limites de ceux-ci s'interpénètrent largement.

On distingue d'abord la flore fongique ou bactérienne, parasite ou saprophyte, responsable ou associée, de ces pourritures, originaire de la plantation ou des hangars et des navires.

Dans un deuxième groupe, il faut rassembler les facteurs concernant la physiologie même des fruits, qu'ils interviennent au cours de la formation ou de la maturation des fruits.

Enfin, nous considérons comme faisant partie d'un troisième groupe les conditions extérieures, tant d'ordre climatique, température et hygrométrie, que d'ordre mécanique et physique, comme la qualité de l'emballage, de la manutention, et les techniques de maturation.

Des conseils sont donnés pour améliorer à chaque niveau la 'qualité' des fruits.

Introduction

L'importance de plus en plus grande donnée aux problèmes de conservation des fruits s'explique certes par les exigences nouvelles des consommateurs en matière de qualité, mais aussi par des soucis de rentabilité économique plus marqués aujourd'hui qu'il y a quelques dizaines d'années.

Pour les seules bananes, si l'on estime actuellement le tonnage mondial commercialisé à environ 4,800,000 tonnes (Cadillat 1968), et raisonnablement les pertes diverses sur cette marchandise de 7% à 15% (dont 3% difficilement réductibles) selon les saisons et les territoires, c'est près de 150 à 300 millions de F qui sont gaspillés chaque année, c'est-à-dire près du volume total des seules importations françaises.

Il est bien évident que les pertes atteignent cette importance parce qu'elles sont supportées par une marchandise déjà très élaborée et par conséquent valorisée entre le stade de la production et celui de la consommation.

Si, d'autre part, les détériorations fongiques sont particulièrement importantes sur les bananes, cela tient évidemment à plusieurs facteurs inhérents au fruit lui-même.

Pour n'en citer que quelques uns, par exemple:

. la récolte brûtale de ces fruits, qui laisse de multiples plaies (coupe de la hampe, découpe des mains et des 'bouquets'), sans qu'aucun phénomène d'abscission, fréquent chez beaucoup d'autres fruits, ne vienne au préalable fermer naturellement les plaies.

. un transport particulièrement long entre les zones tropicales de production et les zones tempérées de consommation préférentielle.

. une période très courte de maturation (quelques jours seulement) favorisant aussi le développement de multiples champignons parasites, présents, latents ou non sur les épidermes des fruits.

La lutte contre toutes ces formes de détérioration sera donc particulièrement complexe et nécessite par conséquent une analyse précise des facteurs les déterminant.

La flore fongique

(a) Origine et aspect quantitatif

Les spores des champignons, parasites ou saprophytes des bananes, sont présentes en permanence dans les plantations où elles survivent en colonisant les débris végétaux de toute sorte, vieilles feuilles, résidus des pièces florales, etc. . .

Leur importance peut varier considérablement d'une région à l'autre, selon les saisons aussi, ou même au cours d'une seule journée (Lukezic and Kaiser, 1966; Lukezic, Kaiser and Martinez, 1967).

Elles sont en général disséminées par le vent et les insectes (*Fusarium roseum k.* notamment) ou entraînées au contact des différentes parties des régimes par la pluie (*Gloeosporium musarum* Cooke et Massee).

Elles sont aussi présentes dans les entrepôts, sur les emballages, dans les cales des navires et dans les chambres de maturation.

(b) Aspect qualitatif

Plus d'une trentaine d'espèces différentes de champignons et de bactéries ont été isolées sur des régimes récoltés en Amérique Centrale (Green and Goos, 1963; Lukezic and Kaiser, 1966; Lukezic *et al,* 1967) en Equateur, aux Antilles, au Cameroun, en Côte d'Ivoire, ou à Madagascar, (Wardlaw, 1961; Brun, 1968; Laville, 1968). Leur importance respective varie sans doute selon les régions géographiques, mais aucune étude comparative ne nous permet de la chiffrer.

Ainsi ont été isolées et identifiées les espèces principales suivantes:

Fusarium roseum k. Verticillium theobromae, (Turc.) Mason and Hughes; *Gloesoporium musarum,* Cooke et Massee; *Botryodiplodia theobromae,* Pat; *Cephalosporium* sp., *Thielaviopsis paradoxa,* (De Seynes) Von Hohn; *Nigrospora oryzae,* (B. and Br.) Petck; *Mucor* sp., *Myrothecium* sp., *Pestalozzia* sp., *Penicillium* sp., *Aspergillus* sp., *Trichoderma viride, Pers ex Fries; Fusarium moniliforme,* Sh. *Curvularia* sp., *Cladosporium* sp., *Piricularia grisea,* (CKe.) Sacc; *Deightoniella torulosa,* (Syd.) Ellis; *Trachysphaera fructigena,* T. et B. etc...

Si certains de ces champignons comme *P. grisea, D. torulosa,* ou *T. fructigena,* engendrent des lésions bien typiques sur les fruits verts qui sont par conséquent éliminés dès l'emballage, les autres n'imposent que très rarement leur faciès propre et les pourritures, atteignant les coussinets par exemple, sont en fait la résultante de leurs actions conjointes.

On note cependant que les diverses parties du régime: hampe, coussinets, pédoncules, et fruit proprement dit, sont colonisées préférentiellement par certaines espèces ou groupe d'espèces (Joly 1962; Laville 1967).

Ainsi, la hampe héberge *T. paradoxa, B. theobromae,* et *Stachylidium theobromae* (Turc.) en plus grand nombre, mais devant la généralisation de l'emballage en mains ou en bouquets, les altérations de cette partie ont vu leur importance décroître.

Les coussinets sont particulièrement envahis par *Cephalosporium* sp., *V. theobromae; F, roseum. G. musarum* et *B. theobromae* (Green and Goos, 1963; Lukezic and Kaiser, 1966; Lukezic *et al*, 1967; Brun, 1968; Laville, 1968).

Ils sont contaminés de deux manières successives. Une première fois, lorsque le régime est encore pendu au bananier, les spores y étant déposées après entraînement par la pluie et, une deuxième fois, durant les opérations de lavage et de coagulation de la sève, survenant après la découpe en mains.

En effet, dès que cesse l'exudation de la sève, on a pu mettre en évidence la pénétration d'une faible quantité d'eau dans les tissus spongieux du coussinet. Avec cette eau, un nombre de spores se trouvent entraînées inévitablement jusqu'à 5 à 10 millimètres de profondeur, dans les tissus fraîchement lésés (Green and Goos 1963).

On remarque en outre que ces espèces se révèlent bien plus actives à la surface et à l'intérieur des tissus lésés que lorsque, comme dans le premier cas, elles sont déposées sur la surface intacte de ces mêmes zones.

Les pédoncules hébergent comme les coussinets un grand nombre de spores appartenant sensiblement aux mêmes espèces.

Certaines se développent sur les pédoncules verts, comme *P. grisea,* ou *D. torulosa,* d'autres ne le font pas aussi nettement comme *F. roseum* ou *G. musarum.* Mais toutes voient leur activité stimulée lorsque les pédoncules sont blessés et le plus souvent à l'occasion de 'pliures'.

Les fruits proprement dits sont colonisés par un plus grand nombre encore d'espèces fongiques et les résidus des pièces florales, encore attenantes aux apex des fruits au moment de leur récolte, en hébergent une grande quantité.

Une mention spéciale doit être faite pour le *G. musarum.* En effet, les spores de ce champignon se déposent à tout moment du développement des fruits sur leur épiderme. Si les conditions le permettent, certaines germent et le filament germanatif se différencie rapidement en un organe de résistance ou 'appressorium'. Cet appressorium, sub ou souscuticulaire, peut demeurer au repos durant de longues périodes dites de 'latence' et ne reprendre une activité parasitaire que dans des cas bien précis.

(1) Sur fruit vert, et uniquement si celui-ci est blessé, au voisinage immédiat du lieu de fixation d'un appressorium.

(2) Sur fruit mûrissant, blessé ou non, et dans ce cas, la transformation du fruit, peau et pulpe, lève la latence des appressorium et la pourriture se développe.

Il est tout à fait probable que d'autres espèces se comportent aussi de cette manière, mais les études précises pour le mettre en évidence restent à faire.

On remarque donc que la majorité des espèces fongiques présentes aux derniers stades de la commercialisation des bananes, ont une activité réduite tant que les fruits demeurent verts et intacts, mais que, par contre, toutes les dégradations (pliures des pédoncules, blessures de l'épiderme, évolution naturelle du fruit et maturation) entraînent une reprise importante du développement fongique.

Ceci peut d'ailleurs être en partie explicité par les relations existantes entre l'évolution des pourritures et le stade physiologique des fruits atteints.

Physiologie des fruits

L'influence de ce facteur est réelle.

Elle s'exerce à deux moments bien distincts de la vie du fruit. La première période englobe sa formation et sa croissance jusqu'à la récolte, la seconde concerne son comportement durant le transport et pendant sa maturation.

Les facteurs agissants durant la première période sont en fait assez mal connus. Ils restent difficiles à étudier, car on ne peut les dissocier les uns des autres.

On sait cependant que la qualité du fruit dépend notamment de la longueur du cycle végétatif durant lequel il s'est développé. Les fruits dits de bonne qualité sont généralement produits au cours d'un long cycle et, inversement, des cycles plus courts produisent des fruits plus fragiles.

Les fumures ont une influence certaine. L'altitude et les alternances de températures agissent aussi. Enfin, l'importance de l'ensoleillement reste à préciser.

Au cours de la seconde période, le comportement du fruit peut être assimilé à une sorte de senescence, dont le déroulement reflète aussi la période antérieure.

On a pu mettre ainsi en évidence des séries de dégradations biochimiques des fruits (Hulton and Proctor, 1961) et l'activité de certaines de ces substances vis-à-vis du développement du *Gloeosporium* en particulier (Razakamanantsoa, 1966).

D'autres travaux ont permis d'isoler à partir des bananes vertes une substance fongistatique, absente des fruits mûrs (Mulvena, Webb and Zerner, 1969).

Conditions exterieures

Il est admis que la croissance des champignons en général est favorisée par des température voisines de 25°C, accompagnées d'un pourcentage d'hygrométrie proche de 90%.

La plupart des espèces isolées des bananes le sont aussi dans ces conditions.

Ce sont elles en fait qui règnent dans les plantations au moment de la coupe et dans les mûrisseries durant les diverses phases de la maturation.

Sur les navires bananiers, les températures sont nettement plus basses 11° à 13°C. mais certaines espèces comme le *F. roseum, S. theobromae, Nigrospora oryzae* (Berk. et Br.) Petch, *T. paradoxa* conservent une activité non négligeable dans ces conditions.

De même l'emballage plastique sous vide partiel permet encore à quelques espèces moins exigeantes (*Fusarium* sp.) de poursuivre leur développement.

Conclusions

Au terme de cet exposé, on perçoit mieux les moments privilégiés où doivent être appliquées les mesures destinées à maintenir les bananes en bon état sanitaire (mesures qui par ailleurs ont déjà reçu un début d'application).

- limitation du nombre de spores en plantation (gainage des régimes et traitements fongicides précoces)
- généralisation des bains de désinfection au moment de la découpe des régimes (action du chlore naissant, du Benomyl, du Mertect (T.B.Z.))
- et surtout manipulations soigneuses à tous les stades du conditionnement.

Il faut enfin rappeler que les travaux d'amélioration de la qualité qui incombent au phytopathologiste prennent dans le cas de la banane deux aspects.

S'il est indéniable que les pourritures des coussinets et des pédoncules représentent un réel problème et doivent être énergiquement limitées, il n'en est pas tout à fait de même pour les multiples taches de faible surface qui parsèment la peau, qui ne nuisent en fait qu'à la seule présentation du fruit, puisque seule la peau est atteinte, mais qu'on demande au phytopathologiste de faire disparaître car il semble que le consommateur actuel achète plus volontiers, avec ses yeux qu'avec son palais.

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Ethylene participation in natural and chemically induced senescence and abscission of citrus fruits and leaves

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Summary

A general symptom of naturally occurring senescence in leaves and fruit of citrus trees is the enhancement of ethylene production by the plant parts. Exposure of the trees to stresses from chilling and freezing temperatures accelerates ethylene production in citrus leaves and fruit and results in acceleration of senescence and abscission of the leaves and fruit. Most abscission chemicals promote ethylene production in the leaves and fruit, apparently a traumatic effect, and the ethylene participates in accelerating senescence and abscission. Cycloheximide fulfills the requirements of an effective citrus fruit abscission chemical by loosening ripe fruit without loosening or injuring green fruit and without excessive defoliation. It is effective at very low levels. The airblast machine removes fruit from the trees very rapidly, but the 110 mph airblast removes some green fruit and leaves regardless of chemical treatment. Ethylene production is enhanced in leaves but not in the green fruit during harvesting by the airblast machine.

Introduction

As a citrus fruit ripens, chlorophyll may decrease and carotenoids increase in the peel, accompanied by flavour and juice changes in the flesh. However, physiologically speaking, ripening is the early stage of the deteriorative processes, called senescence, which terminate the functional life of the fruit. In some respects, the same overall changes (viz. chlorophyll degradation and development of a yellow colour) occur in citrus leaves during senescence. In this paper, we take a unified approach to the senescence problem of leaves and fruit: senescence is a universal phenomena, and the visible changes are easily recognizable. Although the rate of development of senescence in leaves and fruit of many plant species may be regulated by cytokinins, auxins, and gibberellins (Osborne, 1966; Fletcher and Osborne, 1966) and influenced by climate (Reuther and Rios-Castano, 1969) and fertilizer practice (Jones and Embleton, 1959), at some undefined point the senescence process inexorably leads to cell death or to abscission of the leaves and fruit.

Ethylene may accelerate senescence and eventually abscission itself, possibly through its action on enzymes on the cell membranes or walls of the separation layer (Abeles, 1968). Any manipulation of plants which changes the levels of cytokinins, auxins, gibberellins, and ethylene in the tissue may alter the rate of senescence and abscission.

By spraying citrus trees with AA†, and various other chemicals that make fruit and leaves produce ethylene, we alter the rates of senescence and abscission of both leaves and fruit. I will discuss the relevance of these

† The following abbreviations are used for chemical names, with the abbreviations arranged alphabetically and the chemical name following in parenthesis: AA (ascorbic acid), ABA [3-methyl, 5(hydroxy-4-oxo-2,6,6-trimethyl-2-cyclohexane-yl-Cis, trans-4 pentadienoic acid)] or abscisic acid, CEPA (2-chloroethylphosphonic acid), Cycloheximide [beta (2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl) glutarimide], DSA (N-methylaminosuccinamic acid), GA_3 (giberellic acid, K salt), IOAC (iodoacetic acid), NAA (l-naphthaleneacetic acid), and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid).

observations to the practical problems of hastening the colouring of fruit on the tree prior to harvest and the acceleration of fruit abscission as an aid to mechanical harvesting.

Methods and materials

Experiments were conducted with fruit-bearing trees of 'Hamlin', 'Pineapple', and 'Valencia' oranges (*Citrus sinensis* Osb.), 'Robinson' tangerine (*C. reticulata* Blanco), and 'Temple' orange (*C. reticulata* X *C. sinensis*) in commercial orchards in Orange County, Florida.

The trees were sprayed with water solutions of AA, CEPA, cycloheximide, GA_3, and DSA. A surfactant, 0·1% Triton X-100, was added to all test solutions. Ten gallons was adequate to give complete coverage of fruit and leaves of each tree, with some drip to the ground.

A spring pull force tester was employed to measure the effect of the chemicals on the force required to pick the fruit from their stem with a straight vertical pull. The pull force values and leaf and fruit drop are used as indices of abscission. Visible changes in the colour of the peel and leaves and physical and chemical changes in the flesh serve as indices of senescence.

Fruit samples were collected from the trees, and placed in polyethylene bags. The internal atmosphere of 4 to 10 fruit from each tree at each sampling date was analyzed for ethylene content. A hypodermic syringe was inserted through the bag and under the peel of the fruit near the stem end of the fruit. A 2-ml sample of internal air was withdrawn and injected into a gas chromatograph for ethylene analysis (Rasmussen and Jones, 1969). The values given for ethylene content are concentrations of ethylene in parts per 10^9 in the air under the peel.

Because of the difficulties involved in sampling internal atmosphere of leaves, the ethylene production of entire leaves was determined. Ten leaves were placed in a 250-ml Erlenmeyer flask and sealed with a self-sealing plastic cap. Ethylene was determined after 24 hours by inserting a syringe needle through the cap and withdrawing a 2-ml air sample. The values are given as parts per 10^9 ethylene evolved per g fresh weight of leaves per day.

Results and Discussion

Ethylene participation in development of naturally occurring senescence and abscission in citrus leaves and fruit:

The spring flush leaves of citrus normally develop into full-sized mature green leaves during May and remain green all summer, autumn, and early winter. Summer flushes of growth produce additional leaves so that at any time there are leaves of different ages on the trees. Leaf senescence may begin during winter, depending on climatic conditions. Senescence is characterized by a progressive loss of chlorophyll, accompanied by an enhanced production of ethylene (table 1). These processes occur at an accelerated rate during and for several weeks following a frost. Normal senescence and abscission under non-freeze conditions occur at an accelerated rate prior to and during the bloom period in March. Usually, most of the leaves that abscise during March and April are 18-month-old leaves

Young leaves in March were producing more ethylene than when they matured in May. This enhancement of ethylene production in immature leaves is associated with concomitant high levels of free auxin (Cooper, *et al.*, 1969c). These results are in line with Burg's (1968) concept of an auxin-related metabolic system for production of ethylene. The levels of free auxin occurring in mature 2- to 4-month-old Valencia orange trees are practically nil (table 1), and this coincides with the low levels of ethylene production found in these leaves. Auxin levels in freeze-injured leaves and old leaves just prior to abscission that produce high levels of ethylene are not yet known.

The small green fruit developing during March and April produce more ethylene than the 2- to 4-month-old green fruit produce during the summer and autumn. The colour of the peel changes from green or orange with the onset of cool weather. Early maturing varieties, such as Hamlin, usually attain minimum standards of eating quality while the peel is still green in October and November. Low levels of ethylene (less than 4) are found in such fruit. Fruit picked at this stage of ripening require about 20 lb pull force, and the cells at the point of attachment (button) have a creamy-white colour

In Pineapple oranges, a midseason-maturing variety, ethylene increased up to 100 with the onset of cool weather. A loss in green colour and enhancement of orange colour gradually developed during the next 3 weeks and the ethylene content of the internal atmosphere of the fruit dropped to normal levels of around 5 (table 1). A similar pattern of chilling-induced increase in ethylene and of degreening of 'Redblush' grapefruit (*C. paradisi* Macf.) and Robinson tangerine was observed (Cooper, *et al.*, 1969b). As soon as oranges are completely degreened and develop an orange colour (usually in late December), the pull force required for picking drops to near 15 lb and the cells of the separation layer between the stem and the fruit develop an orange colour. Frost injury hastens the development of these symptons of senescence.

The senescence pattern for Valencia oranges, a late-maturing variety, differs in that the Valencias become fully degreened in January and February, and later in April and May they regreen. Such fruit, even though 14 months old, will have a pull force of near 20 lb, and they produce very little ethylene. However, during July 1969, these fruit, though retaining their green colour, softened on the tree and showed enhanced ethylene production (table 1).

Acceleration of ethylene production in leaves and fruit by use of abscission chemicals:

The successful use of abscission chemicals for fruit abscission requires selective abscission of ripe fruit

Table 1.
Ethylene production by orange leaves and ethylene content of internal atmosphere of orange fruits at various dates between October 1, 1968 and July 24, 1969.

Dates sampled	Variety	Age of tissue	Information	Description of leaves	Description of fruit	C_2H_4 leaves parts per 10^9	C_2H_4 fruit parts per 10^9
10/1	Hamlin	6 mo	before cool nights	green	green	3	4
10/1	Pineapple	6 mo	before cool nights	green	green	4	15
10/28	,,	7 mo	after cool nights	green	breaking colour	3	100
12/8	,,	7 mo	after cool nights	green	fully coloured	8	9
12/16	,,	7½ mo	1 day after frost	watersoaked	contained ice crystals	670	41
1/15	,,	8½ mo	1 mo after frost	curled, pale green	95% dry sections	287	58
1/15	Hamlin	8½ mo	1 mo after frost	curled, pale green	75% dry sections	360	134
1/15	Valencia	8½ mo	1 mo after frost	curled, pale green	10% dry sections	100	80
1/15	,,	8½ mo	heated orchard	normal green	no injury	8	9
3/26	,,	12 mo	heated orchard, tree in bloom	normal green	normal	10	4
3/27	,,	18 mo	,,	yellow-green, about to abscise	normal	50	4
3/27	,,	2 wk	heated orchard, tree in bloom	immature	pea sized	86	67
5/21	,,	2 mo	,,	recently mature	small green	8	25
		14 mo	–	–	regreened	-	2
6/4	,,	2½ mo	–	recently mature	small green	4	1
		14½ mo	–	–	regreened	-	4
7/9	,,	3 mo	–	recently mature	immature green	9	1
	,,	15 mo	rainy season	–	regreened	-	36
7/15	,,	15 mo	,,	–	,,	-	40
7/24	,,	15 mo	,,	–	regreened, soft	-	101
	,,	4 mo	,,	mature	immature green	5	3

without causing injury to or abscission of green fruit and without causing excessive defoliation. If chemicals used make ripe fruit produce ethylene, and thereby hasten fruit abscission, the chemicals are likely to make leaves, and possibly green fruit, produce ethylene and cause abscission. In work with AA on Valencia oranges during the summer of 1967, it was found that AA induced ripe fruit to abscise with no effect on leaves or young fruit (Cooper and Henry, 1967). Later, it was established that AA did cause both fruit and leaves to produce ethylene, but more was produced in the fruit than in the leaves, accounting for the lack of abscission response in the leaves. It was concluded that ethylene, itself, participated in the abscission process (Cooper, *et al.*, 1968).

To facilitate the abscission chemical screening, Rasmussen and Jones (1969) tested chemicals for ethylene stimulation separately on leaves and fruit of calamondins (*C. reticulata* var. *Austera* X *Fortunella* sp.?). This was done by using clipped fruit and leaves dipped in the solutions for 1 min and tested for ethylene production. By this procedure, Cooper *et al.* (1968) found that AA, CEPA, cycloheximide, GA_3, IOAC, 2,4,5-T, and ABA caused ethylene production in leaves and fruit to varying degrees (table 2). GA_3 and ABA produced considerable ethylene in leaves, but very little in fruit. CEPA produced moderate amounts in the fruit but excessive amounts in leaves. Cycloheximide caused more ethylene production in the fruit and less in the leaves than CEPA.

Tests with these chemicals on citrus trees in the field generally confirmed that chemicals which stimulated calamondin fruit to produce ethylene caused fruit abscission in the field. However, relative effects of the chemicals on leaf and fruit abscission of oranges in the field did not always parallel ethylene production by leaves and fruit of the calamondin. The relative maturity and degree of senescence of leaves and fruit on trees in the field greatly influence the ethylene production and

Table 2.
Comparison of ethylene evolution from calamondin fruit and leaves dipped for 1 min in water solutions of potential abscission-accelerating chemicals.

Chemical and concentration	Fruit	Leaves
	parts per 10^9 C_2H_4/g fresh weight	
Water (control)	5	8
AA, 1%	40	40
AA, 2%	50	48
Cyc, 5 ppm	25	90
Cyc, 10 ppm	31	152
Cyc, 25 ppm	254	172
CEPA, 500 ppm	18	200
CEPA, 1000 ppm	25	300
IOAC, 500 ppm	27	62
IOAC, 1000 ppm	120	138
2,4,5-T, 500 ppm	25	300
2,4,5-T, 1000 ppm	40	500
GA_3, 500 ppm	3	180
GA_3, 1000 ppm	11	300
ABA, 500 ppm	2	50
ABA, 1000 ppm	1	204

abscission response. The degree of senescence of leaves on the trees in the orchard varies tremendously with fluctuations in the climate, particularly following a frost (table 1). Abscission chemicals that caused no leaf drop on Valencia orange trees during the summer caused excessive defoliation of Hamlin orange trees when applied 3 weeks after frost. The leaves on the latter were producing relatively large amounts of ethylene (table 1) due to the frost and the additional ethylene produced by the chemicals caused excessive defoliation. Likewise, the abscission chemicals generally cause some defoliation of old leaves when applied during February and March just prior to bloom. The classical explanation for this abscission response is that senescent leaves are more sensitive to ethylene, possibly due to a lowered auxin content (Burg, 1968). However, these results suggest that the relatively high natural production of ethylene in senescent leaves in the field, probably enhanced by climatic and nutritional stresses on the tissues, is a large factor in augmenting abscission induced by externally applied chemicals.

AA, IOAC, and cycloheximide probably cause the fruit and leaves to produce ethylene as a result of a traumatic effect. Treated fruit generally show some pitting of the peel. Although objectionable for fresh fruit purposes, the fruit is suitable for processing, as internal quality is unaffected by the treatment (Cooper and Henry, 1967). CEPA does not cause pitting, and is ideal for hastening the degreening of Robinson tangerines prior to harvest. Concentrations as low as 25 ppm are optimal for degreening; whereas, it requires about 200 ppm for leaf abscission and 500 for adequate fruit abscission. When concentrations of CEPA adequate to cause fruit abscission are applied, excessive defoliation occurs, associated with high rates of ethylene production by leaves (table 2). The degreening of citrus fruit with CEPA is an example of a manipulation which alters the rate of senescence by changing the ethylene content.

Acceleration of fruit abscission by cycloheximide:

Cycloheximide functioned both as an inhibitor and promoter of abscission of Valencia oranges (Cooper, *et al.*, 1969a). Solutions of 25 ppm cycloheximide, sprayed on fruit of Valencia orange trees, promoted abscission of fruits coinciding with a marked increase in the ethylene content of the internal atmosphere of the fruit. However, if cycloheximide is injected into the fruit with a hypodermic syringe at a point 2 to 3 mm from the abscission zone, abscission is inhibited, even in the presence of a substantial quantity ethylene in the fruit (table 3). These results substantiate the findings of Abeles and Holm (1967) that ethylene produced by cycloheximide applied at a distance from the abscission zone appears to mask any potential effect of a slowly moving inhibitor.

The cycloheximide effect on abscission of Valencia oranges is rapid. The data in table 4 show that there is a substantial lowering of the pull force of ripe oranges after 2 days; whereas, fruit drop and rind pitting begin after 4 days. Leaf drop was insignificant in this test, as the leaves on the trees were recently mature and were producing very little ethylene.

Table 3.
Influence of placement of application of cycloheximide on the concentration of ethylene in the internal atmosphere of orange fruits and on the average pull force required to pick the fruit 1 week after treatment. Data of Cooper et al. (1969)

Treatments	Pull force (lb)	Ethylene under peel parts per 10^9†
Spray water	13	4
Inject water	-	2
Spray 25 ppm cycloheximide	5	300
Inject 25 ppm cycloheximide	18	150

† There was no substantial difference in the ethylene content in the air under the peel and that in the centre of the fruit.

Table 4.
Rate of fruit and leaf abscission on Valencia orange trees during the first week after spraying with dilute solutions of cycloheximide on 5/17/68. Data of Cooper and Henry (1968)

Observations on ripe fruit†	After (days)	Conc. of cycloheximide (ppm) 0	1	5	10	25
Pull force (lb)	2	16	15	12	11	11
	4	18	15	13	12	8
	7	18	15	12	9	5
Cumulative fruit drop	2	0	0	0	0	0
	4	0	0	4	8	12
	7	4	4	12	12	60
Peel pitting (%)	2	0	0	0	0	0
	4	0	0	0	0	20
	7	0	0	4	22	40
Cumulative leaf drop	2	0	0	0	0	0
	4	1	1	1	1	1
	7	2	2	1	2	2

† The cycloheximide treatment caused no injury, no lowering of the pull force of the small green fruit.

Use of cycloheximide as an aid to mechanical harvesting of citrus:

Cycloheximide has been used successfully in field trials with a commercial airblast harvester and a commercial tree-shaker harvester. On January 1, 1969, an airblast harvester removed 98% of the Pineapple orange fruit on trees sprayed 4 days previously with 10 ppm cycloheximide, but only 60% of the fruit on the control trees. With Valencia oranges, which carry small green fruit as well as ripe fruit, cycloheximide effectively loosened ripe fruit to permit the airblast harvester to remove 96% of the ripe fruit, compared to only 68% of ripe fruit removed from the control trees (table 5). There were fewer stems attached to the harvested fruit sprayed with the abscission chemical than with the controls. There was no direct effect on green fruit or leaves, but the airblast removed about ¼ of the green fruit (golf-ball size) and leaves from all trees. Cycloheximide did not promote ethylene production in green fruit either before or after harvest (table 6). It did promote ethylene

Table 5.
Effect of 25 ppm cycloheximide treatment as an aid to mechanical harvesting of mature Valencia orange trees. Twenty trees, per treatment, sprayed with 10 gal per tree on June 18, 1969, and harvested one week later with an airblast (110 mph wind) harvester travelling at a speed of 3/8 mph.

Treatment	Pull force at time of harvest (lb) ripe fruit	green fruit	Ripe fruit record % harvest	% with stems	% pitted	% decay after 1 wk	Green fruit harvested (%)	Leaves† harvested (%)
Water control, handpicked	15	16	100	0	0	0	0	0
Water control, harvester	15	17	68	25	0	5	29	20
Cycloheximide, harvester	6	17	96	14	21	5	26	25

† There was no leaf drop during the week prior to harvest.

Table 6.
Effect of cycloheximide and airblast harvester on ethylene production (parts per 10^9) in leaves and fruit of mature Valencia orange trees, June 18-26, 1969.

Treatment	C_2H_4 in ripe fruit		C_2H_4 in green fruit		C_2H_4 in leaves		
	5 days before harvest	2 days before harvest	2 days before harvest	1 day after harvest	5 days before harvest	2 days before harvest	1 day after harvest
Water control, handpicked	26	26	<1	<1	4	5	5
Water control, harvester	26	27	<1	<1	3	4	213
Cycloheximide, harvester	148	454	<1	<1	200	20	202

production in leaves 5 days before harvest (i.e., 2 days after treatment), but the rate of production dropped to near that of the controls prior to harvest. The airblast, however, stimulated ethylene production in leaves of both control and treated trees.

A tree-shaker machine was also employed in a harvesting test with cycloheximide-treated Valencia oranges on June 10, 1969. The tree shaker harvested ripe fruit without harvesting green fruit, but the speed of harvesting was slower with the tree shaker than with the airblast machine.

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Discussion

Dr. Lowings: Arran Banner potatoes are grown very widely around the Mediterranean basin and the same variety is widely grown in the U.K. Generally temperatures of 4·5°C are excellent for storage, and I have myself stored Scottish grown seed of this variety at 1°C without damage. However, recommended temperatures for carriage in refrigerated ships are about 4-5°C, but a large number of these shipments from the Mediterranean collapse after discharge. Is it possible that a plant grown in the tropics may be more susceptible to chilling injury than the same plant grown in temperature conditions? Has anyone any experience of this in fruit?

Dr. Fidler: I think that this question has got to be treated from the point of view of the potato, leaving out the fruits. There are a lot of things we don't know. Was the breakdown physiological or bacteriological? Were they refrigerated? Was there a possibility that the potatoes were damaged before they were loaded? Was there a possibility of accumulated carbon dioxide? Cases that have been investigated usually trace breakdown to conditions of carriage and conditions of potatoes at time of loading, rather than conditions while they were growing.

Dr. Lowings: The causes were clearly physiological breakdown, not bacterial. The potatoes were carried in refrigerated spaces, and although I do not think they were frozen, this is possible. Ships' records are notoriously unreliable.

Mr. E. G. Hall: We in Australia have had some experience of the effect of climate on chilling after harvest. Cavendish bananas grown in North Queensland in the tropics are more susceptible to chilling injury than fruits from more southerly latitudes which have matured at lower, sub-optimal, temperatures, and which may have been slightly chilled in the plantation. The latter fruit does not bleed when cut and seems to have been, by lower field temperatures, "pre-conditioned" better to withstand chilling temperatures after harvest.

Concerning potatoes, there is some evidence, from their greater discolouration when processed, due to some starch hydrolysis, that potatoes grown in warmer latitudes are more susceptible to chilling than potatoes grown in the cooler latitudes.

There is no doubt that climate does affect chilling sensitivity. It is well known that apples grown in warmer and drier areas are more susceptible to superficial scald in storage; however, apples grown in cooler moister, maritime climates are more susceptible to internal low temperature breakdown of the flesh in cool storage.

Mr. Coursey: Mr. Hall has said already much of what I intended to say. There is some evidence that material grown in warm conditions is more chill sensitive. It is not unreasonable to suppose that potatoes grown in tropical conditions are more chill sensitive than those from temperature regions, but more research is obviously needed.

Dr. Hulme: In relation to Dr. Cooper's paper on increasing abscission of citrus fruits, I agree that the effect of cycloheximide is almost certainly due to incipient damage. We find that with apple tissue cycloheximide delays ethylene production. However, if the same concentration is sprayed onto whole apples, ethylene production increases and there is damage to the peel of the fruit. Will health regulations allow its use? I wonder whether some other mildly damaging chemicals might have some effect on ethylene formation.

Dr. Cooper: The Upjohn Company that produces cycloheximide anticipates that it will be permitted, and the Food and Drugs Administration have given an experimental permit. Toxicological work is being done with mice and there have not been any snags so far. A spray of 25ppm of cycloheximide can be washed off but one obtains a residue with 50 ppm.

Dr. Hulme: Do you not use peel in the making of juice?

Dr. Cooper: No. Further, residues can be washed off the peel. In regard to your other question, there are a lot of chemicals that cause injury and induce ethylene production but cause too much other damage to be useful. Almost any organic acid will do this. These acids are satisfactory with certain varieties such as pineapple: we got up to 99% harvest with cycloheximide for that. This variety normally loosens and before this harvesting problem arose, they were sprayed to keep them from dropping.

Dr. Callejas: Are mechanical harvesters already used on a large scale?

Dr. Cooper: No; there are a dozen or so in Florida but they only deal with a small proportion of the crop. The growers are very interested but will not use them unless they have to. Mechanical harvesting is a very rough business: in California, people are horrified at the thought of using it. But in Florida it is the only way to get the fruit off the tree.

Dr. E. C. Hall: I am wondering whether the work on cycloheximide has been going on long enough to be able to know anything about the long term effects on the trees? It is a rather drastic treatment: is it in the long term undesirable?

Dr. Cooper: The experiments with cycloheximide have not been going long enough to get long term results. Experimentation with harvesting machines has shown that there has been no drastic reduction in the crop. We do not know all the answers about cycloheximide yet.

Dr. G. S. Randhawa: I would like to know whether you tried maleic hydrazide and triiodobenzoic acid in your experiments. If so, what were the results?

Dr. Cooper: Yes. They were not effective, and caused quite a lot of damage. Citrus are very sensitive.

Fifth Session

Wednesday 17th September
Morning

Chairman
Professor F. Aylward
Professor of Food Science,
Reading University.

Development of the fruit preservation industry in Ceylon

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Summary

The development of commercial fruit preservation by technological methods employed on a factory scale, as distinct from traditional methods, commenced in Ceylon in the post war years. Ceylon gained political independence about this time, and this was a factor which influenced the progress of this activity. The growth of the industry can be traced against the background of the changing patterns of consumption of preserved foods in the country, the pressures of foreign exchange difficulties and the consequent emphasis on local production primarily for import substitution; the absence of personnel trained in this work and the manner in which this problem has been partially overcome using international aid granted as training for local staff. The development of canning as a part of the activities of the Government Department for the Development of (Agricultural) Marketing, the setting up of the Government Canning Factory, its expansion at various stages, the specific difficulties encountered and how they have been overcome with varying degrees of success, are described. Data are furnished for the output of the factory, consumption of raw material, labour, power and containers etc., in manufacture. Investigations undertaken to produce preserved fruit from local varieties are mentioned.

The establishment of several fruit processing factories in the last few years in the private sector, the inclusion of fruit processing industries in the national development plans, orchard-scale fruit cultivation specifically for processing, efforts now being made to provide courses for technical personnel needed to man these industries, and the provision of research facilities to undertake required investigations, form the main features of the changes now taking place in the industry.

The growth of the fruit preservation industry in Ceylon is intimately connected with geographical, economic, sociological, and political factors, and some background information on these aspects is essential for a proper appreciation of the developments that have taken place and of the present problems, their possible solutions and the perspectives for the future.

The most important features of topography and land use in Ceylon are summarized in Figures 1 and 2. Approximately 75 per cent of the total population of 12.5 million, is concentrated in one third of the land, the fertile wet zone, in the south western region of the island, with an annual rainfall of about 250 cm. while the balance of the population is in the remaining two thirds, the dry zone which has only about 125 cm. of rain. Out of the total of approximately 6,450,000 hectares at least half is taken up by forest reserves, irrigation tanks, towns, villages, roads etc., and so not available for agriculture. About 1,620,000 hectares consist of developed agricultural land and a major portion of this is distributed among four crops;

Tea	231,000 hectares
Rubber	229,300
Coconut	466,800
Rice	459,400
Total	1,386,500

The climate varies from tropical humid conditions with average temperatures of 26°C. in the low country to almost temperate conditions in the hills. Combined with satisfactory soil types, this enables the cultivation of many varieties of tropical and subtropical fruits. The main varieties and the principal areas from which these are obtained for processing or marketing are shown in Figure 3.

Imports of preserved fruit products

An important factor which affected the growth of the fruit preservation industry is the change in the pattern of trade in the import of fruit products to Ceylon in the last fifteen years. It is surprising that Ceylon with such an

abundance of fresh fruit should have imported large quantities of preserved fruit from abroad at any time. Even as recently as 1960, considerable quantities of cold stored apples and grapes, dried apricots, raisins, prunes and dates, canned and bottled fruits and fruit juices, jams jellies and sauces, were imported from Australia, the United Kingdom, New Zealand and the Mediterranean countries. In the immediate post-war years, Ceylon was able to afford these imports. However, due to the fall in prices of Ceylon's products in world markets, a rapid increase in population, large expenditure on social upliftment and food subsidies, it became imperative to conserve foreign exchange. Preserved fruit products were among the first items to be affected. These circumstances gave rise to a programme of compulsory import substitution and a consequent rapid advancement of the long dormant indigenous fruit preservation industry. The pattern of decrease in the quantities of imported preserved fruit products and the increase in local production is depicted in Figure 4.

Fruit preservation as a part of agricultural marketing

Commercial fruit preservation was started by the Government Department for the Development of Marketing in about 1940, in the context of its main activities of fruit and vegetable marketing schemes as a means of utilizing seasonal surpluses of fruit. This work progressed very slowly till about 1950. Fruit preservation was regarded as a subsidiary activity of marketing of perishables, its potential as an industry had not been adequately realized and there were no technically trained personnel. Ceylon became a separate nation in 1948, after nearly 500 years of foreign domination. Freedom and independence changed the entire outlook and approach to all activities in the country. They assumed a new significance as national projects with revised objectives. In the 1950's the output of locally produced fruit products rose steadily and by 1962 the imports of similar products from abroad were negligible. This achievement of more or less complete import substitution was made in the face of increasing difficulties of foreign exchange, limited technical know-how and heavy expenditure on social welfare.

The activities of fruit processing and preservation in the Department for the Development of Marketing were undertaken not so much as a commercial enterprise but as a part of a more general scheme for the development of fruit production in Ceylon, with the primary objectives of providing the growers with an assured and lucrative market and the consumers with a high quality product at a reasonable price. To achieve these objectives the Department offered guaranteed floor prices for the fruit from *bona fide* growers. Earlier, in the absence of a market such as was now offered, the prices of fruit especially during the season dropped to levels which were uneconomic to the growers. The guaranteed price also reduced the exploitation of the primary growers by middlemen traders. Under this stimulus, cultivation of fruit, particularly pineapple, increased progressively. In the 1950's pineapple appeared to be the most important fruit for processing because of its highly seasonal nature and its exports potential.

During these years the Narahenpita Factory set up by the Department for the Development of Marketing was the sole means by which the fruits collected under the guaranteed price scheme was converted to a processed and preserved form for distribution. It was possible to export small quantities of canned pineapple from the Narahenpita Factory to New Zealand, the United Kingdom and the Continent.

Development of the Narahenpita Factory

Three small canning units, each with a capacity of about 1,000 cans per day, which had been operating in the early years were replaced in 1956 by a small but fully equipped factory sited at Narahenpita. The development of this Government Fruit Canning Factory and its expansion at various stages will now be outlined.

In 1956, the entire factory and stores consisted only of a single building which accommodated the processing machinery, stores, offices and the laboratory. The layout of the plant is shown in Figure 5. Fruit for processing was received at one end of the main hall and the sequence of operations terminate at the further end, with the canned fruit as the end product. Mechanized fruit cutting was used only for pineapples and even here the process was semi automatic in the sense that fruits were fed singly by hand to the peeling and coring machines. The canning of pineapple slices and pieces as main products and pineapple jam and juice as by-products is shown schematically in the flow chart. This factory, which was capable of handling 5,000 pineapples per 8 hour shift, had to be altered in 1960 as it could not cope with the increased supplies of fruits, especially pineapples, which were now being offered for canning.

Hence in 1960 a new plant, consisting of the existing machinery supplemented with new machines was installed in a new building. This plant was capable of an output of 15,000 pineapples/8 hour shift. Capacity for the manufacture of jam, the main item for import substitution, was also augmented to about 4,500 Kg (10,000 lbs.)/shift. Other important additions were the mechanized removal of refuse, provision of a higher capacity (40 - 60 cans/minute) canning line complete with an atmospheric rotary sterilizer and cooler and a multipurpose double conveyor fruit cutting table for all varieties of fruit which had to be hand cut. Increased production necessitated additional storage space and a stores building was completed in 1962.

The third stage of expansion consisted of another store building for finished products, the extension of the main factory building and the re-installation of machinery according to a new layout in which further new machines were introduced which enabled the factory to take in about 40,000 pineapples per shift. The movement of cut fruit, empty containers and finished products has also been mechanized. This stage of the work is now nearing completion.

There are some interesting and special features with regard to the progress of the fruit preservation work as it has developed at Narahenpita. This canning factory is

operated under the framework of a government department protected and at the same time controlled in its activity by government regulations. The circumstances which have influenced the development of this factory are quite different from those which would apply in the private sector.

Secondly, the factory was not operated with profit as the main objective. The aims were broader based, concerned with the development of fruit cultivation, consumer needs and the conservation of foreign exchange by import substitution. In spite of many disadvantages of working under government regulations and in the absence of the incentives usually found in the private sector, it has demonstrated the technical and commercial feasibility of the fruit preservation industry in Ceylon. Entrepreneurs who are now establishing fruit processing industries find this experience very valuable in formulating their projects.

It is necessary to exercise quality control of the raw materials. Further, the quantities of the fruit have to be regulated for optimum utilization of the cannery machinery. Under the existing arrangements in which fruit is derived from a host of small growers who have no liaison with the factory, it has not been possible to effect any significant improvements in the quality of fruits received. The quantities of fruit obtained are also variable and programming the factory work even over a period of a few weeks is not possible. These drawbacks partly account for the slow advancement over the past years.

The factory, by virtue of the service it has to render as an aspect of marketing of perishable fruit, was required to accept a large number of varieties of fruit, e.g. pineapple, mango, tomato, orange, limes, grapefruit, passion fruit, papaya, beli (*Aeglos marmelos* L.); woodapple (*Feronia limonia* L.); durian (*Durio zibenthinus* Murr.) and jak fruit (*Artocarpus heterophyllus.* Lam.). Often several varieties of fruit had to be processed on the same day, while the finished products included canned fruit, canned or bottled juices and cordials, jams, jellies, chutneys and sauces. It was therefore necessary to have a high degree of flexibility in the development of machines and of labour in the factory. This also meant that the cannery could not be planned fully for any one variety of fruit. However, one advantage of the multi-purpose factory was that it could be kept busy throughout the year.

Training for personnel for technical and managerial work in the factory was made available through organizations such as the Colombo Plan: six of the officers have had such training. Ceylon's fruit preservation industry owes a debt of gratitude for this specialized help from Australia, the United Kingdom and India. The returns from this training are not confined to the Marketing Department Canning Factory. One important function of the factory has been the active help given for the development of the industry in Ceylon, particularly in recent years. Prospective industrialists embarking on fruit preservation have been guided in the project formulation, choice of machinery, factory planning, training of personnel and the solutions of production problems, by the staff at the Narahenpita Cannery.

As an integral part of the development of fruit processing, the Department for the Development of Marketing has undertaken research investigations on the utilization of varieties of fruit other than the traditional pineapple and mango. Beli, woodapple, durian, mangosteen (*Garcinia mangostana* L.), rambutan (*Nephelium lappaceum* L.), and jak fruit are some of the species investigated. In many cases the processing procedures have been worked out for commercial preservation: for instance beli, woodapple and durian canned as nectar or 'cream' are now popular commercial products. This research into better utilization of local fruit, upgrading in quality by improved processing procedures, and the development of new exportable products will be undertaken on an extended scale in a new laboratory to be set up shortly at Narahenpita.

Recent developments

A most significant recent development in the fruit preservation industry is the emergence of the private sector. Up to 1965, most canned fruit and jam production had been from the Government Cannery at Narahenpita. The initiative taken by the private sector is the direct result of the emphasis on industrialization in Ceylon and the active planning by government to establish new industries and thus diversify the economy. Assistance is being given to new industries, in terms of tax exemptions, concessions on foreign exchange allocations and export bonuses. Many medium scale fruit processing factories have already been set up and several more are being established.

Factories now being set up are required by regulations to derive a major portion of their fruit from their own plantations and therefore orchard scale fruit cultivation, specificially for processing, is being practised for the first time. This will enable better quality control and regulation of fruit supplies to these factories.

The phase of import substitution is over and the local market for preserved fruit is limited both geographically and in purchasing power. Manufacturers have become aware of the export potential for tropical fruit and new projects are export-oriented from the start. It is expected that the export of preserved fruit from Ceylon will rise rapidly.

Services to industry

As a result of the rapid growth of industries in Ceylon, the function of the Ministry of Industries has been extended to enable a more active participation, assistance and direction of the activities of industrialization, by the creation of the Industrial Development Board. This, through its component agencies, Investment Bureau, Credit and Industrial Finance Section, Market and Export Promotion Centre, Management Development and Productivity Centre, Technical Services Institute and the Documentation Publications Division, has undertaken a comprehensive service to industry.

The scientific and technological research facilities required to investigate the many problems faced by the new fruit preservation industries are provided by several institutions. The Ceylon Institute of Scientific and Industrial Research is expanding its activities and is expected to undertake short-term problems posed by industries, as well as long-term investigations which have a bearing on industries such as fruit preservation. A separate unit of the Department for the Development of Marketing, the Fruit and Vegetable Utilization Laboratory, will undertake investigations on the various aspects of fruit and vegetable processing pertaining to its own work, especially those immediately concerned with the development of export products. In addition it will provide a centre of service, including training facilities, to the fruit and vegetable industry as a whole.

Another relevant development in this connection is the teaching of food science and technology in relation to the needs of the developing food industry in Ceylon. Apart from *ad hoc* training programmes arranged by the Narahenpita Canning Factory, there have, until recently, been no courses in food science or technology at any institution in Ceylon. Technical know-how has had to be acquired overseas from special courses of study. The number of trained personnel thus produced has been limited. Increased prospects of employment have resulted in a greater proportion of post-graduate trainees choosing to follow courses in food science and technology, but this increase is inadequate to meet the shortage of trained and qualified personnel for the food processing industry and for research. The shortage is most acute in the case of middle level technicians.

In March 1969 the Vidyodaya University of Ceylon commenced a post-graduate course in food science in which eleven graduates are now enrolled. Difficulties of staff and of equipment for practical work have been overcome by drawing on the resources of several laboratories and factories for lecturers and facilities. Students passing out from this course will meet to some extent the need for trained personnel for the food industries including fruit preservation.

It appears that the fruit preservation industry is on the threshold of a major and radically different phase of development in which the private sector will become increasingly important, especially in the export trade. Shortage of foreign exchange is both an impediment and an incentive. Obtaining satisfactory export markets in the next year or two will have a catalytic and decisive effect on the rate of development. Since production to feed these markets has to be based on a thorough knowledge of the market requirements, efficient market investigation and trade promotion should form an integral part of the development programme. The fact that supporting services in terms of providing the scientific technical and managerial skills, extension services in fruit cultivation and in processing, quality control especially as an organized part of the export trade and research facilities are needed, has been recognized and some progress has been made to make these available. Potential for development undoubtedly exists but in order to realize this potential, the industry must be understood as a whole, and integrally planned according to a clarified policy fitting into the country's national programme.

Figure 1
Ceylon – Topography

Figure 2
Ceylon – Land use

Figure 3
Ceylon – Production of various fruits

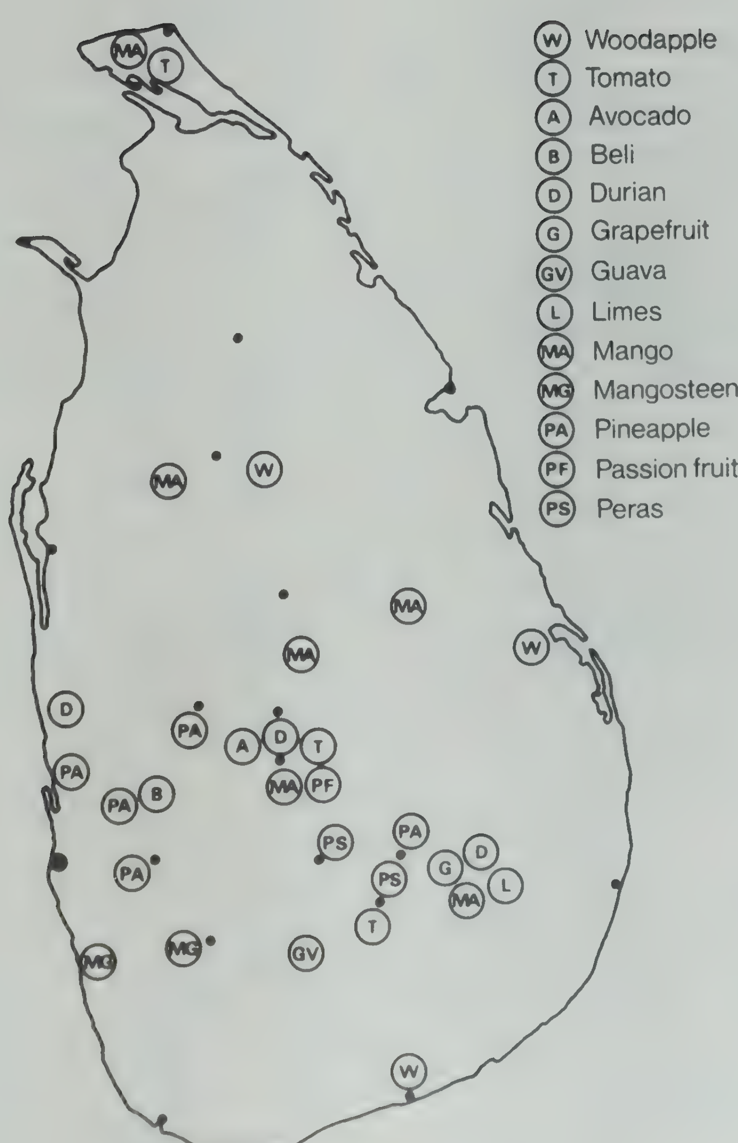


Figure 4
Ceylon – Imports of preserved fruit products and local production

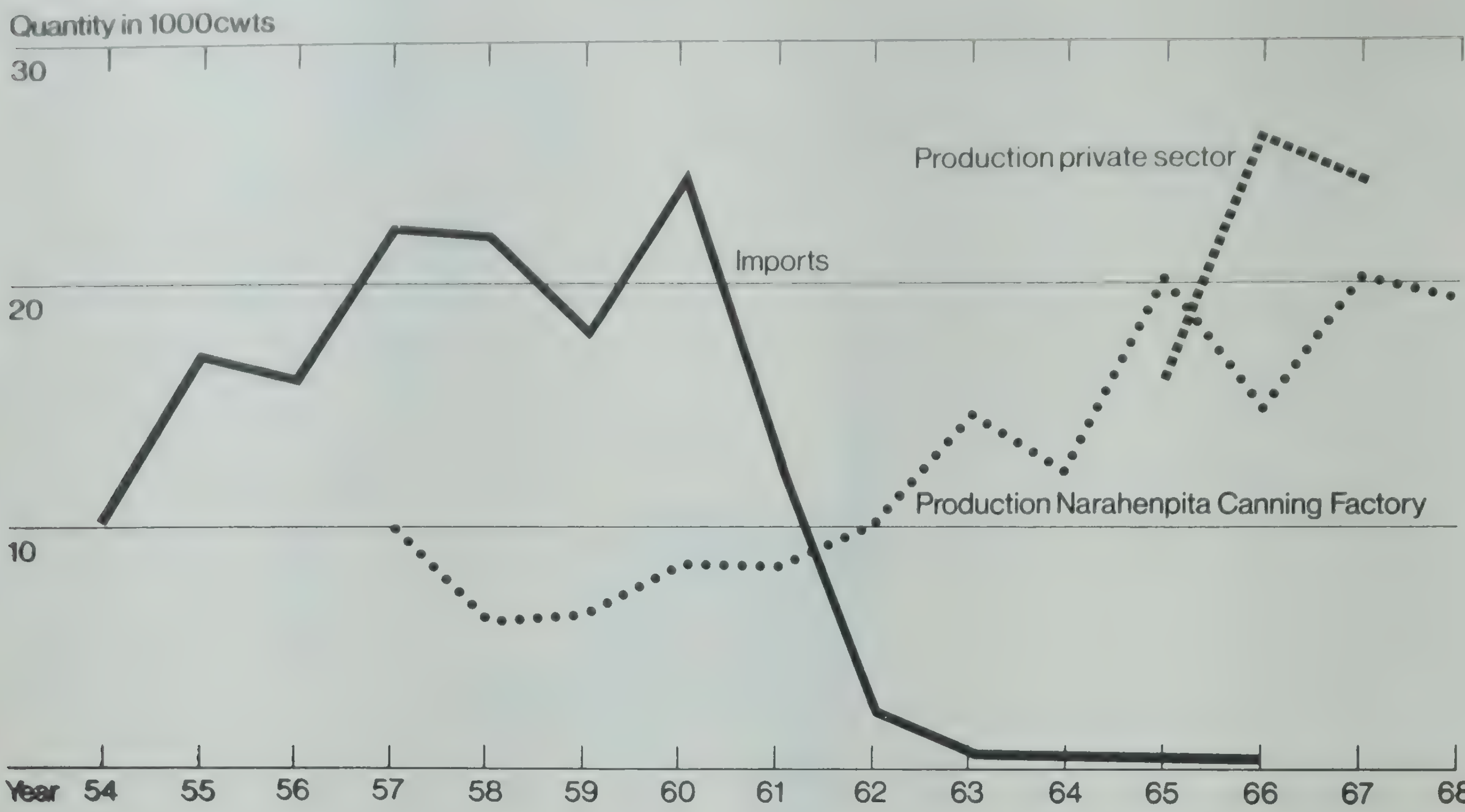
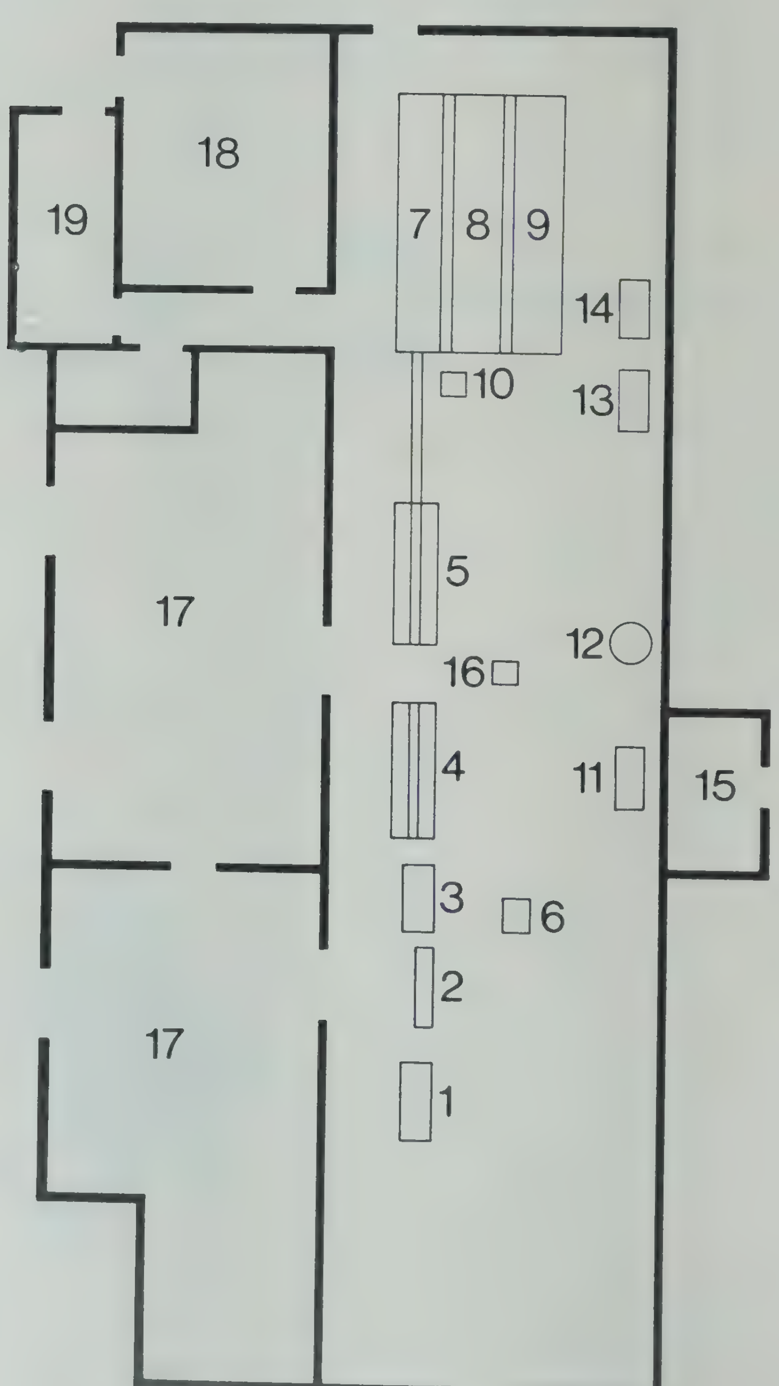


Figure 5
Original layout
Narahenpita Canning Factory,
Ceylon

1 Peeler and Corer
2 Trimming Table
3 Slicer
4 Sorting and Packing Table
5 Segment Packing Table
6 Comminuting Mill
7 Exhauster
8 Steriliser
9 Cooler
10 Seamer
11 Pulping and Sieving Unit
12 Jam Pan
13 Jar Sealer
14 Juice Extractor
15 Boiler
16 Segmenter
17 Store
18 Laboratory
19 Office

(Scale: 1 inch = 16 feet)



The case history of Nkulenu Industries Ltd., Ghana

Esther A. Ocloo

Nkulenu Industries Ltd., Medina-Legon, Ghana

Summary

Big undertakings, such as Smedley's and Bachelor's, whose names are now household words, were established in Europe between the years 1920 and 1930 from very small beginnings, as a result of the economic effects of World War One. Nkulenu Industries Ltd., the first food industry in Ghana, was started with an initial capital of six shillings, in a small kitchen in 1942, as a result of the Second World War.

Miss Esther Nkulenu, having left college in 1941 found that under wartime conditions she could not find a job; coupled with this difficulty was the fact that she had to stay away from her parents who, also as a result of the war, were cut off from her in Togoland – at that time, French territory.

By good fortune, her aunt, a school teacher, sent her ten shillings and out of this she used six shillings to start the making of marmalade. This later developed into citrus fruit juice manufacture, and now canning of Ghanaian dishes. The name 'Nkulenu' which is the maiden name of the founder, is now a household name in Ghana, and by now to a Ghanaian conveys nothing but food. The industry, although quite small, is known for the high quality of its products. This experience shows that with determination, hard work and tenacity of purpose man can achieve even what is apparently impossible, even from the smallest beginnings.

It is interesting to learn that many big undertakings, like Smedley's and Bachelor's Peas, which are now household names, were built up in Europe between the years 1920 and 1930 from very small beginnings as a result of World War One. In a similar manner Nkulenu Industries Ltd., the first food industry in Ghana was started with six shillings, in a small kitchen as a result of the Second World War in 1942.

Necessity is the mother of invention, so the saying goes. My ambition when I was in school was to become a medical doctor, but as fate would have it, the war conditions made this impossible for many private students, so it became necessary for me to look for a job, but, again, because of the war, jobs were also very scarce. With my parents far away on their farms in Togoland (then under French Mandate), I had to live with some relatives in Accra, who, did all that they could to help me; yet judging from the conditions under which I was living in the boarding school, life was tough and challenging to me. To write for help from my parents could not yield any results because the war affected all means of communication between the then Gold Coast (now Ghana) and French Togoland. I could have written to my aunt, a school teacher, who looked after me in College, but judging from what she had to sacrifice to make it possible for me to finish my schooling, and also, what the relatives with whom I was staying would say, I decided to forget about it and leave it to fate.

A whole year had almost passed without any sign of getting a job; and it was quite a relief and exciting when I received a letter from my aunt to the effect that she was coming to spend her school holidays with us. A week after the receipt of the letter she arrived and stayed for three weeks. Having seen everything for herself, before her departure, she promised to send me some money. Six days after, I received a ten shilling postal order from her. I wasted no time in running to the Post Office to cash the money. I could hardly express my joy over the sight of the money. A thousand and one ideas passed through my mind. One thing I still remember and that is, the repeated statement I made myself 'I must get twenty shillings out of this ten shillings'. Affirmations do work, and have worked for me on several occasions.

Fortunately, it did not take me more than twenty minutes to decide how to work this miracle. Owing to

the war, quite a number of items could not be imported into the country, and one of these items caught my mind, and spontaneously I shouted out, 'Yes, I must make marmalde!' Without more ado I took my basket, ran to the market and collected all the necessary things for making marmalade, namely sugar, oranges, lemon, charcoal and jars; (these I collected at about one in the afternoon) at a total cost of six shillings. Marmalade normally takes two days to make, but by nine o'clock that same day, my marmalade was ready. I got twelve jars of nice, clear jelly marmalade ready for the market the following morning. I got up more than three times that night, for it seemed the day would never come. I was so excited I could not sleep peacefully. Six o'clock found me all dressed up after having filled my basket with the twelve jars of marmalade. Before eight o'clock I was in the city going from office to office, store to store selling my marmalade. By ten o'clock my dreams had come true. I sold the twelve jars for twelve shillings. If only I had used up all the ten shillings I would have got the twenty shilling I had envisaged. I felt like a millionaire.

By the end of the third month of the project I engaged two women to help me with the boiling and selling of the marmalade. During this time I had also started supplying my former college with marmalade and pineapple jam. The progress of the venture was remarkable. The news went through the whole country like wildfire, because in those days a Ghanaian girl with the type of education and the certificate I had was regarded very highly, while hawking was the job of people who had never been to school, and to hear that I had taken to that puzzled the nation. The business took a bigger turn when I was called upon to supply the West African Frontier Forces with orange squash. This was a wonderful opportunity, but it posed a big problem, because up to that time I had no factory and all I had were three aluminium boiling pots, some few yards of muslin, two sieves, three knives and two tables. This time I could not take twenty minutes to decide what to do as I did on the day I received the ten shillings. The money I had saved was far too small to finance the contract. Not knowing where to raise a loan from I decided to use the money I had saved for erecting a temporary factory, buy more equipment and arrange to obtain on credit the raw materials like sugar, bottles, firewood and corks. It took me two weeks to get the place ready for the Army Health Officer's inspection. The first thing I did was to look for a carpenter to accompany me to the market where left over building materials were sold. After collecting all the necessary materials, and loading them on a horse and a cart the carpenter and I sat by the driver and rode to the factory site. This contract which helped me to make quick money lasted for a little over two years, but as a result of this contract, the industry is the sole supplier of fruit juice to the Ghanaian army hospitals to this day.

It was quite a surprise to many people, including friends and relatives, when by the end of the sixth year I left for Britain to study large scale cookery and food preservation. The help given me by both men and women in appreciation for my efforts in Britain was very remarkable. These benefactors still write to me and send me useful technical information. To make my course thorough, it was arranged, after the theoretical part of the training, to take an additional course in fruit juice manufacture under Dr. V. L. Charley, the fruit juice expert, formerly of Beecham Foods, and courses in microbiology of canned foods, practical can making and canning with the Metal Box Company Ltd. I was back home in 1951 to improve on the industry which was kept going by a relative and a small staff. After some eleven years hard struggle, the year 1962 found the industry in its own new building. The factory, which is ten miles away from the city of Accra, has four main sections; fruit juice, canning, jam and marmalade and baking and catering sections. The products on the local market are:—

Squashes
Orange and Lime Juice
Sweet Orange
Lime Cordial
Pineapple Jam
Jelly Marmalade
Groundnut Soup
Palm Soup
Cream of Palm Fruit
Beans in Dzomi
Jollof Rice
Cakes and Pastries.

The size and the capacity of the plants can supply at least 50% of Ghana's requirements of fruit juices, jams and marmalade. Except for preserved unsweetened juice for storage against the off-season, no preservative chemicals are used in the fruit juices we manufacture; they are all treated by heat processing. Pure lime juice is also used to provide the additional acidity required instead of citric acid as it is used in other countries. No chemical is added to our squash to make it look cloudy, sugar is the only thing used to sweeten it.

The main tropical fruits used by the factory at the moment are citrus fruits and pineapples. The different kinds of fruit juices we produce are made from fresh oranges which come into season twice every year.

Our marmalade is made of three fruits, namely oranges, grapefruits and sour oranges, lemons being used when sour oranges are not available. The oranges in Ghana differ a great deal from those of the Mediterranean countries, Israel, and other countries known for citrus fruits. The skin is very thin and the colour dull and they are not suitable for making marmalade without additional acid and pectin, hence the need for the use of grapefruits and sour oranges to provide these. Really, in a country like Ghana where other citrus fruits with high acid and pectin content abound, the use of commercial pectin and acid is unnecessary.

Pineapples are not being grown on any commercial scale in Ghana and until there is sufficient quantity to warrant an installation of peeling and slicing plant, our industry intends using pineapples for jam only. Pineapple is one of the poorer fruits for making jams and here again we use the liquid prepared for marmalade manufacture to provide the required pectin and acid, but at times it becomes necessary to add some commercial pectin to help with the setting. Although fruit juices, jams and marmalade were the two main products on which I built

the industry, my interest in specializing in packing of indigenous Ghanaian foods increases everyday. For this reason after returning from Britain in 1951, the first thing I concentrated on was experiments in canning as many Ghanaian foods as possible. The Metal Box Company again was very helpful in this undertaking. We use palm fruits and groundnuts for soups, okra, garden eggs, peppers and tomatoes with fish for gravies (which we call in Ghana by different names according to the tribe). The local white beans were also used with seasoned palm oil for the experiments, and 'Beans in Dzomi' a high protein food, is the outcome. This product is served with gari (which is roasted, fermented cassava) a frequently used product in Ghana.

A new product developed two years ago is the "Cream of Palm Fruits". This new product is very much hailed by the women of Ghana and the African people overseas, and it is one of the products which will stand a favourable chance in overseas markets where people of West African origin abound. This product is the milky part of the palm fruit which is sieved out after the fruits are steamed and pounded. The cream is finally filled hot into cans, sealed and processed. It is used for palm soup which is served with boiled rice, yam, gari etc. As a result of experiments in the use of rice the product "Jollof rice" was also developed. This is a complete meal in itself, consisting of rice cooked in meat stew. This product is highly patronized by the Ghana army, who find the jollof rice pack very handy when on manoeuvres. Gari is the cheapest food in West Africa but it is often prepared by the women under very poor hygienic conditions. Apart from this, its presentation on the markets and keeping quality are not up to standard, and in line with my plans to improve on processing and packing of indigenous Ghanaian foods this problem was also given attention by carrying out extensive experiments. The result of this experiment is one of the achievements which have made 'Nkulenu Industries' great in the eyes of the people in Ghana. The 'Okom Asa' (meaning 'Hunger is no more') brand gari is clean, crisp, fine and packed in polythene bags, well sealed. As it has always been the case, the firms which help in the marketing of our products were not prepared to handle it, unless we distributed it to them to try on a 'sale or return' basis. Nevertheless, the response given by the consumers was tremendous. It is rather a pity to have to say that we were forced to discontinue production because of the high cost of cassava.

This paper would not be complete without commenting on the part the Baking and Catering Units have played in maintaining the industry. After my return from Britain in 1951, it became very difficult to get enough market for fruit juices and marmalade; to keep the industry going because the Army contract was no longer big or regular. Imported fruit juices and marmalade were also extensively stocked by the larger stores. The consumers also did not accept locally made goods readily at that time; it therefore became almost impossible to rely solely on these products for a living. To save the situation I had to go in for the baking of cakes and pastries for the stores and catering for cocktail parties and other social entertainments. It is this department which provides 'Butter and Bread' as we always put it. On the whole the progress of the industry has been extremely slow, and the reasons are varied and many. Some difficulties are similar to those experienced by food industries in other developing countries, while others are peculiar to Ghana. Lack of capital, reliable sources of raw material supply and marketing have been the major problems.

In conclusion I would like to point out that Ghana, being a tropical agricultural country, stands a very good chance in fresh tropical fruits trade, as well as canning and bottling of tropical fruits and fruit juices. In fact this could happen very easily if the right types of fruits could be grown on a large scale.

At the moment, the above mentioned problems make it exceedingly difficult for us to keep up a steady production, or to think of expanding the business with the view to entering the world market. At times it is highly challenging and frustrating; but when I pause for a while, and look back, I say to myself that there is no going back. For, if I think of bad breaks at the early stages of the industry, the difficulties I had in getting consumers and the firms to accept my products; and then think that now the name 'Nkulenu' has become a household name in Ghana and also that at the Food Conference organized in Accra by the Food Research Institute and FAO in 1967, 'Nkulenu' Orange Squash came first out of the collections both of local and imported squashes, I have no cause to be demoralized or impatient. All I need now is a bit more tenacity of purpose, sacrifice and hard work. With the Ghana Government's new policy on agriculture and plans to help indigenous Ghanaian enterprises it may not take too long a time to see my dreams for Nkulenu Industries come true completely.

Technological advances in the pineapple industry in Queensland

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Summary

In the post war years, the Queensland pineapple industry has shown a marked development and expansion, due in no small measure to the advances made in the scientific and technological aspects of pineapple processing. With a view to increasing yields and producing uniformly high quality fruit with high recovery and improved consumer appeal of the canned product, a long term research project was commenced over nineteen years ago. An intensive selection and propagation programme was conducted, followed by trials of agronomic performance and canning suitability; these have reached the stage where several clones have been selected as having the most desirable characteristics. Canning evaluations have necessitated finding means of determining ripeness in pineapples and have revealed many important relationships in the physical and chemical characteristics of pineapples.

Although the basic technology of pineapple canning is much the same the world over, economic considerations in Australia have necessitated particular attention to by-products, especially pineapple juice and juice blends as well as tropical fruit salad. Unpalatable juices extracted from solid waste can be converted by fermentation to satisfactory vinegar.

A number of physiological and microbiological disorders occur in pineapples in the field and their incidence results in variable recovery of flesh, a matter of considerable economic importance.

A feasibility study for a tropical fruit cannery in Central Queensland recently completed provides valuable data and a framework for anyone conducting similar studies elsewhere.

Industry Development

Delegates here today will probably be interested to know that pineapples were first grown in Queensland about 100 years ago, from planting material from Kew Gardens.

However, organized marketing was not developed until the 1920's when a growers' organization known as the Committee of Direction of Fruit Marketing (COD) was established. It had the power to allocate supplies of pineapples to several small canners but without uniform marketing of the canned product there was little impetus to expand production.

The demand for pineapple products rose sharply during the Second World War and some expansion took place. Following the war, industry leaders recognized the need to stabilize the industry and to develop world markets. In 1947 the COD established its own cannery which has steadily expanded to cope with increasing production. The Golden Circle Cannery as it is now known, is a co-operative cannery independent of the COD. It is claimed to be the largest fruit cannery in the Southern Hemisphere and handles over 90,000 tons of fruit per year, over 80 per cent of which are pineapples.

Crops

During the past 20 years the crop has grown from 32,000 tons to 110,000 tons, of which about 85% is processed.

Pineapples are grown along the 1,600 km eastern coastal regions of Queensland but 75 per cent of the production is in the southern area; central Queensland produces about 24 per cent and north Queensland less than 1 per cent. Lower production costs in the tropical areas would tend to suggest that advantage should be taken of this but the distances from markets and other essential services and supplies is a deterrent to increased production in this area.

There are two main crops in Queensland, summer crop (December to April) and winter crop (July to November) which yield about 55 per cent and 35 per cent respectively of the total and the balance from an intermediate

*Paper read *in absentia* by E. G. Hall.

crop in May-June. In southern Queensland the plant crop is obtained about two years after planting and the ratoon crop 12 to 14 months later. In the tropics, fruit may be harvested within 15 months of planting. The plant and first ratoon crops normally constitute the commercially productive life of a pineapple plant. Artificial flower induction using a 10 ppm solution of alpha naphthyl acetic acid (ANA) can be used to reduce the harvesting peaks and thereby reduce plant capacity requirements.

The main variety is the smooth Cayenne which is suitable for both the fresh fruit market and processing.

Research

Following the war, as the industry developed and processing was subjected to more exacting scientific control, it became obvious that there was a considerable variation in both the physical and chemical characteristics of factory pineapples.

In the hope of isolating consistently superior strains of pineapple, with higher yields, better recoveries as well as improved consumer appeal and with a view to eventually standardizing the type of pineapple grown, a number of selections were made in 1950–51 by officers of the Maroochy Horticultural Research Station.

This intensive selection programme based on shape and size of fruit, suckering and slipping potential and absence of deformities was carried out over a period of several years after which thirty clones were selected. This was followed by a propagation programme and trials to test agronomic performance and canning suitability.

To make comparisons between clones at a period of maximum palatability, a technique based on the translucency of a 12 mm. pineapple slice was developed by Bowden (1967a) following work initiated by CSIRO (Leverington, 1968a). He selected slices from a cannery line and sorted them into three translucency ranges by means of a translucency meter. He showed that there is a correlation between translucency and palatability. As expected, the canned fruit did not exhibit the same differences between translucency ranges as fresh fruit.

Bowden (1969a) has reported further trials with selected clones to investigate more fully the relationship between translucency and a number of quality characteristics. Maximum palatability corresponded to a point between semi-translucent and translucent. In general, the clones resembled each other fairly closely with respect to the relationship between translucency and other characteristics. However the relationships between skin colour and each of the other characteristics studied were extremely erratic confirming that skin colour is a poor index of ripeness. During the final ripening stage, fruit weight, pH, TSS/acid ratio and total ester concentration increased and acidity decreased with increasing translucency. TSS, flesh pigments and palatability increased to a maximum in the medium range of translucency and then decreased with further increase in translucency.

A small percentage of pineapples differ from this pattern and can be opaque, highly flavoured and light to rich in colour.

Using fruit of equal ripeness based on translucency, clonal evaluation trials have been conducted, using a number of characteristics as a measure of canning suitability (Leverington, 1968a; Bowden, 1967a; 1967b; 1969a).

Fruit weight is of major interest to the grower as it is directly proportional to the yield per acre.

From a recovery viewpoint, a *maximum diameter* of 134 mm (5 1/4 in.) appears desirable.

Flesh recovery is dependent not only on fruit size but also on *fruit shape* which is determined by two ratios namely length ratio and taper ratio. *Length ratio* is defined as length/average diameter and is normally between unity and 1.8. The higher the figure, the higher the canning recovery for a given diameter.

Taper ratio is the ratio of fruit diameter at 3/4 length to fruit diameter at 1/4 length, zero length being the base. Badly tapered fruit has low recovery and high trimming labour costs. A taper ratio as close to 1 as possible is desired and this can be obtained with a good square shouldered fruit. Pineapples showing a taper ratio between 0.95 and 1.05 and a length ratio greater than 1.50 have an excellent shape for canning purposes.

External colour development in pineapples is important because the skin and adhering flesh is pressed to express the juice. Cannery fruit should therefore be as well coloured as possible for the correct stage of ripeness. As a general rule for a given ripeness the smaller the fruit the more coloured it may be externally.

Physiological defects such as large or non-central cores are regarded as defects since a portion of the core will not be removed mechanically during peeling and coring.

Translucency besides being an index of ripeness is a major factor influencing the appearance of the product. Semi-translucent to translucent highly coloured slices are generally considered to be most attractive and have the best flavour.

High translucency fruit have an overripe flavour and lack acidity, while the low translucency fruit are lacking in pineapple flavour and are too acidic (Bowden 1967a, 1969a).

Internal colour also affects product appearance and acceptability. As the fruit ripens the creamy-white flesh changes to the desirable golden yellow. This colour development is usually very rapid during the final maturation stages and continues into senescence.

Porosity should be at a minimum because flesh of a very porous fruit is riddled with air cavities which show up as jagged edges in slice and piece packs. As the fruit becomes more and more translucent these air cavities decrease somewhat in size.

Total soluble solids (TSS) of pineapples have been found to vary from a daily average of about 9 per cent in winter to about 14 per cent in the summer with individual fruit as high as 20 per cent (Leverington 1962a). Apart from

taste, the TSS is of economic importance to the canner as he has to use about 20 per cent more sugar in winter than in summer.

Acidity and pH affect palatability: the average daily acidity based on factory fruit varies from 1.0 per cent in winter to 0.5 per cent in summer, with acidity being closely related to ripeness. According to the work of Singleton and Gortner (1965) which has been confirmed by the Food Preservation Research Laboratory, the acidity rises significantly as the fruit ripens and about 10 days after a peak is reached the fruit is at optimum ripeness based on consumer acceptability. The acidity falls away sharply after the peak. This corresponds to the development of translucency mentioned previously.

Leverington (1962a) reported that there is a tendency for fruit to be less acidic when grown in the tropics and pH values above 4.5 have been recorded. This problem can be overcome by application of suitable quantities of potash during development.

There exists a wide variation in TSS/acid ratio between summer and winter fruit, the average being about 9 in winter and 28 in summer. The summer fruit is therefore much sweeter than the winter fruit and is consequently much more attractive.

The palatability depends not only on TSS/acid ratio but also on the concentrations of volatile flavouring constituents, mainly esters. A close study of *total volatile ester concentration* in clonal trials and factory samples has shown that it is closely related to ripeness. Only a trace of esters has been detected before the flesh starts to colour from which stage there is a steady rise to 30–50 ppm (in summer fruit) followed by a very steep rise as senescence sets in and the fruit becomes overripe. The monthly average total ester concentration of freshly expressed pineapple juice has been found by Leverington (1962a) to vary from 20 ppm during July to 60 ppm during early summer and late autumn months.

The texture of a pineapple is important to the consumer as well as to the canner. Casimir, Mitchell and Lynch (1962) have reported two methods of studying this characteristic. Bowden (1967b) considered that their methods may be unsuitable for clonal evaluation as only a portion of a slice was put under strain to determine break strength. He developed a centrifugal device to determine break strength in which a whole slice was placed under strain and showed that break strength thus measured was correlated to breakage on factory lines.

It may be many years before the pineapple industry can be converted over to the use of the selected clones but the selection has been narrowed to two.

Blemish in Fruit

Leverington (1968a) has described various blemishes which may render all or part of the pineapple unsuitable for canning.

Black heart is the major blemish affecting pineapples and it normally occurs in the winter crop. It affects the fruit internally in the vicinity of the core, starting as brown water soaked spots about 2 to 3 mm. in diameter arranged symmetrically in the flesh a few centimetres from the base and about 1 cm. from the core. These spots increase in size, then merge, spreading inwards, outwards and upwards until the whole of the flesh and core may be affected. Generally no external symptoms are obvious. No organism is responsible for this disorder but there is some evidence to suggest that it results from physiological disturbances brought about by unfavourable weather conditions particularly sudden drops in temperature during maturation.

Water blister is caused by a fungus penetrating the fruit through an injury and results in the flesh being soft and watery. The covering skin becomes very brittle.

Yeasty rot is caused by an infection of yeasts gaining entry through injuries and results in a spongy yellow flesh and the evolution of gas bubbles. Farm and handling hygiene is the principal control measure in both these cases.

Brown spot or fruitlet core rot is not detectable externally but can result in heavy trimming of the fruit prior to canning. The brown areas are generally confined to the individual fruitlets but may spread to the surrounding tissues. This blemish results from microbiological infection through insect damage of the flower, and appears to be more liable to occur at certain times of the year.

Marbling is a bacterial disease causing the formation of hard brown and white patches in the fruit.

Pre-harvest Treatment

Bowden (1969b) showed that although ANA sprayed onto pineapples about 2 months before harvesting increased fruit size and weight by about 20 per cent, it caused a decrease in TSS, TSS/acid ratio and flesh colour, and prevented the development of high quality flavour. It also results in the development of overripe flesh at quite backward levels of skin colour. The use of ANA for fruit enlargement has therefore been prohibited (Seale 1967; 1968).

Solid Pack Processing

Pineapples in bulk bins each holding about 3/4 tons are delivered to the canneries where they are weighed, inspected, and washed before being fed to Ginaca sizers and corers. The cylinders of pineapples are then trimmed manually and cut into 1.25 cm. slices by a single or multi-blade machine. The slices are then graded according to the degree of trimming and breakage and the best slices packed into cans, the next best slices and broken slices are cut into pieces by a segmenter and packed into cans. Most of the remaining pieces are diced and

blended with syrup and packed as crisp cut crushed pineapple. The total recovery of the flesh packed varies from 21 to 33 per cent.

Leverington (1962b) investigated the utilization of locally produced washed first grade raw sugar for pineapple canning syrups, but discolorations and abnormal flavours were produced, rendering the canned pineapple unacceptable.

Leverington (1962c) also investigated the production and storage of frozen pineapple and showed that air blast freezing at (−32°C.) −25°F. or lower and steady storage temperature at (−17°C.) 0 to (− 12°C.) 10°F. gave the highest drained weight value.

For many years there was a steady market for tropical fruit salad prepared from pineapple segments and similar large sized pieces of papaya and other fruits, but crushed small-cut pineapple was difficult to sell. A finer fruit salad mixture was therefore developed using crisp cut pineapple and papaya as well as banana, passion fruit and orange juice. This product permitted the development of efficient mechanical handling equipment including a continuous pre-mix filling system which reduced labour costs and produced a popular economically priced product.

Juice Processing

Beverage Juice

The balance of the pineapple is utilized for the manufacture of beverage juice coming mainly from flesh up to 2.5 cm. thick adhering to the skin; the cores and the trimmings. The solid material is pulped and then fed into one of several kinds of juice extractors, usually a screw press, depending upon the degree of extraction required. All the juices are blended together and passed through a plate heat exchanger to destroy most of the micro-organisms, precipitate protein and control viscosity. Seale (1968) has indicated that viscosity changes causing settling problems will occur if this heating is not correctly carried out. The heated juice is then prepared for canning or bottling by passing through a conejector screen and a self opening centrifuge to clarify it to below 0.5 per cent solids.

Fruit Juice Drinks

The recent introduction of more efficient juice recovery equipment has permitted further diversification to be undertaken with the introduction of canned fruit drinks with a high juice content. The main ones available at present are pineapple-orange, pineapple-grapefruit, pineapple-apricot and a tropical fruit punch containing pineapple, papaya, peach and orange juices.

Vinegar

By subjecting pineapple skin residues to a second pressing at higher pressures an unpalatable juice can be expressed. A procedure has been developed by Spurgin (1964) and Richardson (1967) for converting this juice into vinegar by submerged fermentation. Trials with pilot equipment indicated that:

(i) An anti-foam agent is required to control foaming.

(ii) It is necessary to acidify the stock to 2 per cent to prevent contamination by undesirable strains of yeast.

(iii) It is essential to use an inoculum in the logarithmic phase of growth if a long lag period is to be avoided.

(iv) Vinegar containing 7 per cent acetic acid can be prepared in less than 24 hr. with a conversion efficiency of greater than 90 per cent provided temperature is maintained between 29° and 30°C.

(v) Agitation of the fermented juice is most important.

Concentrated Pineapple Juice

Leverington (1962a), Leverington and Morgan (1964, 1967; (1968b) have described the development of an experimental pineapple juice concentrate plant with an ester recovery system.

Satisfactory processing techniques have been developed for the concentration of beverage pineapple juice and storage conditions have been studied. The marketing of pineapple juice has undergone considerable expansion and change since this project was commenced over 10 years ago and at present no juice is available for concentration for either the local or export market.

Cannery Feasability Study

In view of the increased production of pineapple in central Queensland during recent years and the desirability of establishing secondary industries away from Brisbane, a study to determine the feasability of estabishing a tropical fruit cannery in central Queensland has been conducted by Hall, Leverington and Wiltshire (1969). Aspects investigated include size factors, (fruit availability, canning output and plant capacity), factory design, and processing techniques, cost factors, marketing, profitability and diversification. The report provides valuable data and a framework for anyone wishing to conduct a similar study in any other part of the world.

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Processing and preservation of some lesser-known fruits of India

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Summary

India's fruit and vegetable preservation industry started about thirty years ago with pioneering investigation on the preservation of citrus squashes and cordials. The initial success of these products led to the processing and preservation of a variety of other regional fruits, employing other methods such as canning, dehydration, preparation of jams, jellies and marmalades, ketchups, sauces, vinegar etc. Laboratories were set up in different parts of India, in order to develop the methods for preservation of both major and minor fruits. From 1949 onwards, with the establishment of the Central Food Technological Research Institute at Mysore, fundamental, as well as technological work on many of the less-known fruits of India was intensified and a series of papers published.

Banana, papaya and passion fruits were of special scientific, nutritional and commercial interest. Among the minor fruits from which a variety of products were developed, mention may be made of ber, pomegranate, mulberry, musk melon, water melon, amla, jaman, carambola, sapota, custard apple, cashew apple, wood apple, mangosteen, tamarind, bilwa, lychee, jack fruit and karonala.

Once specific problems of individual fruits have been overcome, the fruits may be processed in such a way as to bring out their characteristics, if this is required, to provide interesting and unusual products.

This work has opened up further avenues for horticultural development in India, not only for the fruits mentioned but also for the many fruits of which very little is known.

India's fruit and vegetable preservation industry started about thirty years ago with the pioneering work of Lal Singh and his colleagues. At the Punjab Agricultural College, Lyallpur, simple methods were developed for the preservation of citrus squashes, cordials, etc. The success of these products led to further work on various fruits, employing other methods of processing and preservation such as canning, preparation of jams, jellies and marmalades, dried and dehydrated products, ketchups, sauces and vinegar. Laboratories were set up in Poona, Quetta and Kodur to develop the preservation industry, utilizing local fruit and vegetables. Initially most investigation was devoted to major fruits, but later, the importance of finding means of processing and preserving a number of lesser-known fruits was realized. With the establishment of the Indian Institute of Fruit Technology at Delhi in 1945 and its transfer in 1949 to Mysore as the nucleus of the Central Food Technological Research Institute under the Council of Scientific and Industrial Research, it became possible to undertake detailed investigations on several of the lesser-known Indian fruits and vegetables. Early work has been highlighted in "Preservation of Fruits and Vegetables" published by the Indian Council of Agricultural Research. Further data are, however, found only in various published papers, which are reviewed here.

Ber (*Ziziphus jujube* Mill).

There are two kinds of this fruit, namely small (*chota*), and large (*mota*) ber. It is highly valued as being nutritious and protective on account of its ascorbic acid content, and is often used on ceremonial occasions. Investigations as early as 1937 showed that the fruit could be candied or dried. (Siddappa, Unpublished work).

Date (*Phoenix dactylifera,* L.)

Work was taken up to determine the proper stage of ripeness for the dehydration of dates, and a simple home drier was developed.

Loquat (*Eriobotrya japonica,* L.)

Conditions were standardized for the canning of this fruit, which grows in the Punjab, Uttar Pradesh and Bihar, and for the preparation of jam. The pH of the fruit was reduced for canning by acidifying the syrup.

Pomegranate (*Punica granatum* L.)

The most popular variety of pomegranate is kandahar, which has large juicy grains. The purplish red juice is generally of 16 - 18° Brix, 0.8 - 1.2 per cent. acidity, as citric acid, and the tannin content varies from 0.12 - 0.18 per cent. depending upon the method of extraction (Siddappa, 1943a).

Methods have been standardized for making a variety of food products (Siddappa, 1943a). These include juice preserved by over-flow pasteurisation or by addition of sodium benzoate; pomegranate syrup, and a thick, sweetened product known as *Anar-rub* used as a sauce. The seeds can be dried into a product called *Anardana,* used as an acidulant in cooking.

Mulberry (*Morus spp*).

The mulberry bears fruits which may be either white, purple or black. The white mulberry yields 40 - 45 per cent. juice of 21 - 23° Brix and 0.4 - 0.5 per cent. acidity, while the black mulberry yields 65 - 70 per cent. juice of 17 - 18° Brix and 1.5 - 1.6 per cent. acidity. Both juices can be preserved as syrup by pasteurisation. (Siddappa and Mustafa, 1946).

Musk melon. (*Cucumis melo* L.)

Melons of excellent quality are grown and consumed in large quantities in many parts of India. Melon jam of golden yellow colour and excellent flavour can be prepared. The flavour can be further improved by adding lemon slices or ginger pieces (Siddappa and Mustafa, 1946). Melon slices or cubes can be canned alone or in the form of mixed fruit cocktail (Siddappa and Bhatia, 1958). Melon syrup, of about 60° Brix and 1.5 per cent. acidity, preserved with potassium metabisulphite, can also be prepared.

Water melon (*Citrullus lanatus* (Thunb) Mansf.).

The thick rind of the fruit can be converted into candy similar to candied ash gourd (*Benincasa* spp.) which is popular in many parts of North India. It can also be used for the preparation of chutney. The pulp yields an attractive pinkish, mildly flavoured juice, but on pasteurisation the colour deteriorates to light brown. The juice is about 8° Brix, and can be converted into a syrup of 60° Brix and 1.5 per cent. acidity and preserved with sodium benzoate. On storage, there is fading of the colour and settling of the pulp. (Siddappa and Mustafa, 1946).

Amla (*Phyllanthus emblica* L.)

This fruit has a high vitamin C content, stabilized by the tannins present. Amla preserve or 'Murabba' is an important candied product. Similar candied products are made from *Harar* (Myrobalan) and apple. Recent investigations (Sastry and Siddappa, unpublished work) on the beneficial effect of *amla* preserve in reducing the cholesterol content of blood is of considerable significance. The changes in ascorbic acid and tannin contents during the preparation of *amla* preserve have been studied. (Sastry and Siddappa, 1959).

Jack fruit (*Artocarpus heterophyllus* Lam)

These fruits often weigh as much as 25 - 30 kg. each, the outer surface being covered with numerous short spikes or spines. Inside, there are a large number of edible segments each enclosing a seed. Fruits which have large segments of crisp texture and sweet, fragrant taste are preferred to those of fibrous texture and mild flavour. A use has been reported for practically every part in a series of papers (Bhatia, Siddappa and Lal, 1955a; b; 1956a; 1956b; 1956c; 1956d). The segments, which have a pH of 5.5 - 5.6, can be canned in acidified syrup to give an exotic flavoured product of good shelf life. The segments can be converted into pulp for the preparation of jam, nectar, or fruit toffee, or dried in the form of sheets and slabs. Osmotic dehydration has been successfully employed. Other useful products are simple or mixed fruit jams or preserves, chutney, concentrate and powder. The perigones surrounding the bulbs, and also the thick, pectin rich rind can be utilized for the preparation of jelly. (Siddappa and Bhatia, 1952a). The starchy seeds can be roasted or boiled in salt water, processed into flour, or canned in brine as a curried vegetable. Investigations have been carried out on the effect of processing on the trypsin inhibitor in the seed (Siddappa, 1957). This was of interest in view of the belief that the seed is indigestible unless cooked. Unripe jack fruit can be canned as a vegetable as slices in brine or in spiced gravy. Feeding trials have studied the value of fresh and of canned jack fruit, with or without honey, in poor rice diets (Siddappa and Bhatia, 1957; 1955a): no supplementary value was found, although incorporation of honey had a beneficial effect on growth.

The seeds are rich in calcium, protein and carbohydrates (379.5 mg. per cent. 12.4 per cent. and 78.3 per cent. respectively). The seed flour has a slightly bitter taste, which is not eliminated by treating the seeds with salt or bicarbonate solution (Siddappa and Bhatia 1955b). The

bulbs of jack fruit are rich in sugars, mostly sucrose, glucose and fructose (Bhatia, Siddappa and Girdhari Lal, 1955c). They contain 16.2μg./100 gm. of beta-carotene, but are poor in vitamin C (7.8 mg./100 gm.). In canned jack fruit, retention of beta-carotene is high, 91 per cent. at 25 - 28°C. after 26 months storage. There is practically no corrosion of the can at 25 - 30°C. after 15 months storage. The fruit can be canned successfully mixed with Bangalora variety of mango (1:2 or 1:3), at a pH of 3.9 - 3.6 (Siddappa and Bhatia, 1956). A study has been made on the role of pH in the canning of jack fruit. (Bhatia, Siddappa and Lal, 1956e).

Physico-chemical changes in jack fruit squash during storage, (Bhatia, Siddappa and Lal, 1956f) and retention of added ascorbic acid in canned jack fruit during processing and storage (Bhatia, Siddappa and Lal, 1957), have also been studied. Methods have been standardized for the preparation of pectin, pectin extract and syrup from jack fruit wastes (Jain and Lal, 1957) and rind (Bhatia, Siddappa and Lal, 1959). The yield of crude pectin from the rind and core is 1.2 per cent. in ripe, and 0.4 per cent. in unripe fruit. The pectin content is highest in the inner portion of the rind, (Bhatia, Siddappa and Lal, 1959). Tin in canned jack fruit products during prolonged storage was found to be within the permissible limit of 285 mg./kg. (Bhatia, Siddappa, Lal, 1958).

Cashew apple (*Anacardium occidentale* L.)

On the West Coast of India, a thriving cashew nut processing industry has been built up, the processed kernels finding an extensive market in USA, Europe and elsewhere. The 'fruit', popularly known as cashew apple, is actually a bulbous, fleshy appendage of the cashew nut. It is a truncated cone, 7.5 cm. long by 5 cm. in diameter. The flesh is soft, juicy and has an attractive orange yellow to purplish red colour; it has high sugar, mineral and vitamin C content, but an astringent taste.

Although the nut commands a world-wide market, the fruit is seldom consumed in large quantities on account of its astringent taste, and short post-harvest life. Limited amounts are utilized around Goa for the preparation of a fermented liquor, 'Feni'. Preliminary investigations at the Kodur laboratory showed that the fruit was an excellent raw material (Siddappa, 1943b) for the preparation of a variety of products such as juice, syrup, candy, etc. The juice was extracted in a basket press. It was generally of 10° Brix and 0.2 per cent. acidity, as citric acid. It was heated to coagulate the proteins and to prevent enzymatic browning. After settling, it was blended with about half its weight of lime juice to enhance the acidity. After removing the copious flocculent precipitate, the clear juice was converted into a sweetened beverage, cashew apple syrup, preserved with potassium metabisulphite. Both the colour and taste improve during storage.

The possibility of setting up a processing industry based on cashew apple has been examined (Jain, Das and Lal, 1952). The polyphenol constituents in cashew apple juice are dependent on region, strain and selection (Sastry, Lakshminarayana, Satyavathi, Pruthi and Siddappa 1962). The polyphenol and ascorbic acid content of the fruit undergo considerable changes during candying (Chakraborty, Sastry, Pruthi and Siddappa, 1962). Steaming of the fruit for about 10 minutes at 10 p.s.i. reduces the volatile corrosive oil content of the juice. Cashew apple candy is a potential commercial product: it is soft and resembles dried fig. Much data has been collected on the preservation and storage of cashew apple juice and its blends (Sastry, Chakraborty, Pruthi and Siddappa, 1963), and as a concentrate (Pruthi, Chakraborty, Sondhi, Sastry and Siddappa, 1963). Experimental data has also been collected (Singh and Mathur, 1953), on the storage life of the fruit.

Papaya (*Carica papaya* L.)

Papaya is employed for canning, preparation of jam, and nectar-like products. Extraction of papain from the unripe green fruit on the tree does not affect the pectin content of the fruit or its ripening. This has opened up a new vista for the processing of papaya, both papain and pectin being highly important commercial products. (Das, Siddappa and Lal, 1954). After extraction of papain, a proportion of the fruits can still be utilized for the preparation of high grade pectin. (Siddappa and Krishnamurthy, 1965; Bhatia, Krishnamurthy and Lal, 1959; Jain and Lal, 1955). Part of the crop can be allowed to ripen on the tree without any deleterious effect on quality for processing and preservation in the form of products such as canned cubes or slices, jam, nectar, fruit slab or preserve. Detailed studies were carried out on the two important by-products, papain and pectin, on a pilot plant scale (Krishnamurthy, Bhatia, Lal and Subrahmanyan, 1960; Sarode, Krishnamurthy and Siddappa, 1964). Methods have been standardized for the preservation of ripe papaya pulp by canning and dehydration (Das and Siddappa, 1955).

Processing of some minor fruits

In some parts of India, there are fruits which are not of any commercial importance at present. These are, however, of considerable scientific interest and may be potential sources of important nutritional factors.

Chalta fruit (*Dillenia indica*, Lin)

This fruit of Assam has been studied in a preliminary way for preservation (Pruthi and Lal, 1954).

Banegara fruit (*Randia dumetorum*, Lam)

This fruit, which is found in Mysore State, is boiled to remove excess tannins and then eaten as a vegetable. It has been analysed for its nutritive value (Siddappa and Bhatia, 1952b).

Garcinia xanthochymus Hook.f.

This fruit is found in Mysore State. The proximate composition of the fruit has been determined and methods standardized for its preservation (Mahadeviah and Siddappa, 1966).

Amate Kayi or Indian Hog Plum (*Spondias mombin* L.)

This fruit, which is valued for its vitamin C content, is employed for pickling or preserving as in the case of *Amla* (Siddappa, 1953).

Palmyrah Palm (*Borassus flabellifer* L.)

The palm kernel which is of soft texture and mellow flavour, called *'Nungu'* in South India, is prized as a cooling food. It is preserved by canning and candying (Siddappa and Bhatia, 1955c). The carbohydrates have been investigated (Subrahmanyan *et al*, 1956).

Tamarind (*Tamarindus indica* L.)

Ripe tamarind fruit are used extensively in Indian cooking as an acidulant. They can be converted into a preserve. The pulp is a good source of tartaric acid, and can be processed into a concentrate for use in sauces, etc. (Lewis, Dwarakanath and Johar, 1954b).

Bilwa fruit (*Aegle marmelos* (L.) Correa)

The ripe fruit can be quartered and preserved, as in the case of *Amla*, or the sweet, astringent pulp converted into a beverage. The polyphenol content is essentially
? tannin (Siddappa, 1958).

Wood apple (*Feronia limonia* (L.) Swing)

Wood apple has a hard shell and an acidic sweet pulp of light brown colour surrounding a large number of seeds. The pulp, which has a mild, pleasant flavour, is used as a refreshing beverage during hot weather. Pulp and seed have been analysed and the methods for preservation standardized (Srivas *et al.* 1965; Subhadra *et al.* 1965).

Jaman fruit or *Jambolana fruit* (*Eugenia cuminii* (L.) *Druce Falsa*)

Both of these fruits have been processed into excellent sweetened beverages. Further work is necessary regarding their chemistry and nutritional values.

Mangosteen (*Garcinia mangostana* L.)

The soft, juicy pulp of mangosteen, which is white or rose coloured, possesses a delicious flavour and aroma. It may be canned as segments or used for the preparation of a sweetened beverage. From the hard rind, a jelly can be prepared (Siddappa and Bhatia, 1954).

Sapota (*Achras zapota* L.)

Sapota is being grown on an increasing scale. The oval, egg-shaped and the round varieties, all of which have a light brown pulp of a characteristic flavour, are well liked. The pulp is soft, but gritty, so that satisfactory canned segments, jam or beverages, cannot be made from it. Further work is necessary to investigate other preservation methods. Cold storage of the fruit has been studied. (Singh and Mathur, 1954).

Carambola (*Averrhoa carambola* L.)

Carambola is an ovoid, angular, fleshy and juicy fruit, 7 - 12 cm. long, of a rich amber colour. There are two distinct kinds, one sweet and edible, and the other being rather acidic in flavour. Both varieties have been utilized for the preparation of squash, jam, jelly and candy (Siddappa, 1959). Acids and sugars present in the fruit have been determined (Lewis, Dwarakanath and Johar, 1954a).

Avocado (*Persia americana,* Mill)

Avocado has been introduced recently into India and is at present of minor importance only. It has been found possible to prepare freeze-dried avocado powder and preserve it. This is of considerable interest in view of the relatively high oil content. (Siddappa, Sastry and Nair, 1965).

Custard apple (*Annona squamosa,* L.)

Custard apple grows wild in the Deccan. The juicy pulp, surrounding numerous black seeds, is creamy white, possessing a sweet taste and characteristic aroma. Canning has not proved successful as the pulp develops bitterness and a pinkish tint on heating. Preliminary work on freeze-drying has been encouraging.

Karonda (*Karonda carondis,* L.)

This fruit has been found to be suitable for candying, the product resembling glacé cherry.

Durian (*Durio zibethinus,* Murr.); *Langsat* (*Lansium domesticum* L.)

Studies have been carried out on the cold storage of these two fruits with a view to further processing investigations (Mathur and Srivastava 1954; Srivastava and Mathur, 1955).

Hard pear (*Pyrus* spp.)

Varieites of pears such as William and Bartlett, suitable for canning, are grown in some districts. In Madras State, however, hard pear varieties are found and little data is available regarding their processing. Modified methods for canning halves and quarters, preserve, juice, chutney

and jelly have been evaluated (Mookerjee, Tandon and Siddappa, 1963).

Litchi (*Litchi chinensis*, Sonn)

The white fleshy pulp of the litchi, covering the seeds inside a thin, roundish, spiny shell of 2 - 4 cm. diameter, is soft and juicy and possesses a characteristic taste and aroma. The high pH of the pulp renders it necessary to acidify the canning syrup, which affects taste and flavour. In China, the fruit is dried and exported. Some work has been undertaken on canning segments and dehydration. Small quantities of litchi squash are manufactured.

Passion fruit (*Passiflora edulis*, Sims.)

Since 1949 when a brief note was published on passion fruit squash (Siddappa, 1949), much interest has been created and a series of fundamental and technological investigations carried out (Pruthi and Lal, 1959).

Banana (*Musa* spp.)

Some major varieties can be processed into products such as canned slices, jam, drum-dried flakes, spray dried powder, custard powder, banana fig, deep fat-fried banana chips, and fruit bar or slab. The foam mat drying technique also has been found suitable for the preparation of banana juice powder (Nanjunda swamy *et al*, 1965).

Banana pseudo-stem, normally a waste material, is a source of high quality starch, intermediate between cereal and tuber starches (Subrahamanyan *ét al*, 1957). The edible core can be preserved as candy, canned product or dehydrated slices (Nanjundaswamy and Siddappa, 1964). From the pulp scraped from the peel of the fruit, a cheese-like product can be prepared.

There is considerable scope for further work on the processing and preservation of many less known fruits so that they could be exploited on a commercial scale. The scientific data obtained will be of fundamental importance, opening up further avenues for horticultural development in the country.

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Problems of fruit processing industries in West Pakistan

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Summary

Pakistan produces tropical and subtropical fruits such as citrus, mangoes, pomegranates, dates, grapes, pears, guavas and mulberry. Owing to their perishable nature, these must be preserved for utilization during off seasons. The fruit processing industries are yet in the developing stage and are faced with many problems.

Problems for export purposes include high raw material and processing costs, non-availability of proper packing facilities, high inland and ocean freights, complexity of marketing and uneven and improper quality of products. For domestic purposes, the general problems being faced by canning industries, cold storage plants, dehydration factories and fruit juice concerns include improper selection of factory sites, inefficient procurement and marketing of fruit and fruit products, inconsistent and substandard quality of products, absence of liaison between scientists and industrialists, high cost of imported processing equipment, inefficiency of labour and unsatisfactory hygienic conditions.

Introduction

Pakistan, in general, and West Pakistan in particular are well known for the production of all sorts of tropical and subtropical fruits such as citrus, mangoes, pomegranates, dates, grapes, apples, pears, peaches, guavas, pineapples, papayas and mulberry. Fruits are important nutritionally as sources of vitamins, sugars and minerals. However, these are perishable and must be either consumed quickly or preserved for consumption throughout the year. The consumption of fruit in our diet is very low at 39 pounds *per caput* per annum as compared to other countries like USA, Israel, Spain, UK and Brazil where fruit consumption stood at 225, 222, 85, 84 and 53 pounds *per caput* per annum respectively. Our diet is low in protein, vitamins and minerals.

Owing to inadequate marketing, storage and preservation facilities, the wastage of fruit may be up to 20%. Fresh fruits and fruit products are already in great demand abroad and this demand is expected to increase.

The organizations of fruit processing industries on modern lines is essential for conserving surplus fruits. The present paper is an attempt to dilate on this industry and its problems.

A brief history of the development of fruit culture and preservation is presented in Table 1.

Export of Fruit Products

Reports of the Trade Promotion Bureau of the Government of Pakistan indicate the possibilities of exporting fruit and fruit products to the Middle East, South East Asia and some European countries. For instance fresh fruits such as citrus fruits, bananas and fresh figs are exported to Netherlands, Bahrein, UAR, Afghanistan, Saudi Arabia, Iran, Switzerland, UK, Persian Gulf States and Singapore; mangoes, apricots, pears, pomegranates, peaches and plums are being exported to France, Italy, Austria, Ceylon, Iraq, Lebanon, China, Aden, Kuwait and Afghanistan; dates are being exported to the UK,

Table 1
Growth of Fruit Culture and Fruit Preservation

Year	Nature of development	Type of fruits and their products
1926	Acreage of Fruit Plantations in former Punjab stood at 1,990 hectares	Mangoes, citrus fruits, dates
1937	Large number of cottage-sized Fruit Factories developed	Juices, squashes, cordials, jams, jellies, canned fruits
1939	Canning Industry developed	Canned fruits and vegetables
1945	Fruit Products control order promulgated	Quality control emphasized
1947	Acreage rose to 42,070 hectares out of which West Punjab shared 2,348 hectares. Acreage in West Pakistan raised to 48,590 hectares	Mangoes, citrus fruits, guava and mulberry
	Fruit Factories increased to 457 out of which 207 developed in areas constituting West Pakistan. Only seventy survived	Canned fruits, canned vegetables, canned juices and jams
1950	Pakistan Government granted licences to 108 concerns for new factories	-do-
1955	Ten large sized factories developed	Juices and squashes
1960-65	Capacity of existing factories planned for increase to 2,814 tons, 261 tons and forty-five tons for canned fruits, fruit juices/concentrate and citrus oils	Canned fruits and vegetables, fruit juices and concentrates and citrus oils
	Total acreage rose to 1 41,800 hectares and total production 1,6 68,835 tons	All varieties of tropical and subtropical fruits
1965-68	Fifty and half lakhs rupees invested on setting up large and small plants	Canning of fruits, fruit juices, syrups, preserves, pickles, jams, jellies and marmalades
1965-70	Planning took place for investing twenty-five lakh rupees for modernization of existing big factories	-do-
	125 lakh rupees allocated for setting up new large size factories	-do-
	Twenty-five lakh rupees allocated for setting up new small size plants	-do-

Kenya, Tanzania and Mozambique; and fruit peels are being exported to Malaysia (Afridi 1959, Ishaq 1960, Chaudhry 1969).

Jams and jellies are being exported to the UK and the Persian Gulf States; fruit juices are being exported to USA, Belgium, Germany, Italy, Netherlands, Sweden, United Kingdom, USSR, Bahrein, Lebanon, Malaysia, Singapore and Thailand. Exports of canned and preserved fruit and vegetable products stood at thirty-four lakh rupees (1963-64) and forty-two and a half lakh rupees (1964-65) with a final target of a total export value of one hundred lakh rupees.

Recent enquiries show that consumption of fruits in the fruit processing industry in West Pakistan is not more than two per cent of the total production whereas in developed countries, the industrial consumption may be more than seventy-five per cent. If export has to be boosted, industrial consumption must be increased which will also ensure better return to the grower and maintenance of a stable price-level throughout the season. Various difficulties may be briefly summarized as follows:

High cost of raw material: Oranges in Pakistan are bought at about ten rupees per maund while same fruit is procured at four to six rupees per maund in other countries such as Florida, Greece and Israel. This high cost in our country is due to low yield, too many middlemen engaged in procuring the fruit, uneconomic transport, unscientific method of packing and lack of suitable varieties for particular processing operations, (Ahmed, 1969).

High processing cost: The processing cost of fruit and fruit products is high due to higher costs of imported equipment, high fuel and electricity charges, processing operations running at less than full capacity and high cost of sugar and chemicals. These factors tend to make the price of processed products uncompetitive in the international market.

Non-availability and high cost of containers: Fresh fruit meant for export should be graded and each grade packed properly in individual wrappers, impregnated where appropriate with suitable fungicides such as diphenyl or orthophenylphenate. In many advanced countries, fruit products are canned in sixteen ounce

(tall) cans, which are convenient and attractive to the consumer. Such cans are not manufactured in Pakistan thus creating a great handicap to export of canned fruit products. A simple price-comparison for the containers based on data reported by Chaudhry (1969) shows the costly nature of locally available cans.

Table 2
Price of cans (in Pakistan currency)

Type of can	Local price (Hashmi Can Company, Karachi)	International price
	Rupee Paisas	Rupees Paisas
Can No. 2	0.58	0.24
Can No. 2½	0.75	0.34
Can No. 12	1.71	0.85
16 oz. (tall) can	0.58	–
	(if imported on bonus vouchers)	

Similarly the cost of labels, pilfer-proof caps, glass bottles and jars is two to three times higher than usual international prices.

The cost structure for squashes given in table 3 shows that if packing and raw materials were obtained at international prices the cost would be approximately half of the present manufacturing cost (Chaudhry, 1969). There is need to develop a local packing industry on modern lines in order to expand exports.

High inland and ocean freights: The freight between Australia and London is approximately 175 shillings per ton of fruit but from Karachi to London, it is 340 shillings per ton. Similarly the ocean freight from Japan to Jeddah is less than that from Karachi to Jeddah. Non-availability of space in unscheduled sailings of steamers makes the situation much worse especially for perishable commodities. Other countries are providing subsidies in inland and ocean freights by giving top-priority in the shipment of perishable items.

Export marketing problems: Demand in foreign countries depends upon established buying habits of consumers, consumer's behaviour, economic conditions, trade structure practices and import procedures. There is a need for the Fruit Processing Industries to station permanent Trade Representatives in importing countries who may assess market trends and promote personal contacts for effective competition with the right type of products. The Pakistan Government have already taken steps to help the exporters through the Export Promotion Bureau, the Pakistan Trading Corporation and Export House.

Variable quality: The local industry is not well-versed in the quality of products required by foreign countries and only few concerns have well-equipped quality control laboratories manned by suitably qualified personnel. The products often do not conform to optimum quality standards (Anon., 1967). The Department of Food Technology, West Pakistan Agricultural University, has so far trained eighty B.Sc's., fifty-two M.Sc.'s and one

Table 3
Cost structure of squashes (45° Brix) per crate of 12 glass bottles (26 ounces capacity each).

	Prices of Products					
	Mango squash		Lemon squash		Orange squash	
	Local	International	Local	International	Local	International
I *Juice Base*						
a) Cost of juice base	6.00	6.00	7.00	7.00	11.00	11.00
b) Cost of sugar at Rs. 65/- per maund	7.75	2.38	8.10	2.48	7.30	2.24
II *Packing costs*						
a) Bottles: 12.5 at Rs. 0.69	8.38	3.70	8.38	3.70	8.38	3.70
b) Labels large: 15 at 0.4	0.60	0.25	0.60	0.25	0.60	0.25
c) Labels small: 13 at 0.02	0.26	0.15	0.26	0.15	0.26	0.15
d) Glue	0.10	0.05	0.10	0.05	0.10	0.05
e) Pilfer-proof caps: 14 at 0.11	1.54	0.98	1.54	0.98	1.54	0.98
f) Carton	3.25	1.12	3.25	1.12	3.25	1.12
III *Labour*						
a) Cost of filling machine	0.33	0.16	0.33	0.16	0.33	0.16
b) Labour	0.42	0.50	0.42	0.50	0.42	0.50
IV Depreciation and overhead expenses	2.00	2.00	2.00	2.00	2.00	2.00
TOTAL:	30.63	17.29	31.98	18.39	35.18	22.15

Ph.D candidates majoring in Food Technology. Some graduates are also trained at the Agricultural College, University of Peshawar. Nevertheless, local industrialists have been slow to employ food technologists even though the latter are now locally available in sufficient numbers. The Government is earnestly impressing on industries the need to employ the right man for the right job and it is beginning to get a favourable response.

Problems of Fruit Processing Industries

The fruit processing industry of West Pakistan consists mostly of canning plants, cold storage plants and fruit juice processing concerns and their problems may be categorised under two main headings, as follows:

General Problems

Improper selection of factory sites: Except in few cases, most factories have been installed without giving due attention to their proximity to the production areas, availability of skilled and unskilled labour, the supply of power and water, season of operation and availability of cheap as well as fast communication facilities. These tend to increase the production costs of fruit products.

Procurement of raw material: Picking and packing methods are primitive, too many middlemen are involved in marketing, and transportation is costly as well as time-consuming. Farmers market their produce in mixed form and no scientific data are available on suitability of different varieties for various processing operations. Farmers should be trained in scientific picking and packing methods, grower's cooperative societies should be formed for the economic procurement of fruit and refrigerated transport vans be introduced for the safe transit of fresh fruit (Ahmed, 1969).

Lack of liaison between scientists and industrialists: There has been very little communication between the food scientists and industrialists in the past. Industrialists were not prepared to adopt new techniques and there was little urge on their part to avail themselves of the findings of research workers. Many new processes for new fruit products have been patented but none has been adopted so far at the industrial level. (Rafiq and Bhatti, 1966; Sattar and Bhatti, 1966). Functional committees comprising of the members from related branches of teaching, research and industry were formed by the Scientific and Technological Research Division of the Government of Pakistan to establish liaison between scientists and industrialists. The formation of a Fruit Processing Advisory Committee has also been suggested (Roy, 1969).

High cost of imported processing equipment: Most of the processing equipment is imported on bonus vouchers which makes them very costly. The developed countries may look into the question of supplying fruit processing equipment at concessional rates to developing countries for stimulating their industries.

Costly marketing procedures for processed foods: Marketing procedures involve many middlemen such as wholesalers, retailers and commission agents who raise the price of products.

Specific Problems

The dehydration industry is poorly developed as industrialists hesitate to invest capital into it, owing to uncertain marketing opportunities. The first few factories should be set up by the West Pakistan Industrial Development Corporation to infuse confidence amongst investors.

The cold storage industry is facing the difficulties of insulating material, shortage of qualified food engineers and non-availability of proper packing containers for cold storage of fruits and their products. 'Foam-Concrete' developed by the Pakistan Council of Scientific and Industrial Research, Karachi needs to be tried for insulation purposes. To meet the need for food engineers, degree courses in this subject should be started locally and until these facilities have been evolved, the developed countries may look into the question of offering training facilities to Pakistan in this subject.

The imported washing equipment used in the fruit juice industries is not adapted to local varieties of fruit. Bottled juices change in taste, flavour and colour if exposed to sunlight. There is need to conduct local research for evolving new fruit washing equipment and controlling damage to juice due to sunlight.

For domestic consumption, research efforts should be directed to developing protein-rich and fruit-flavoured drinks by adding synthetic amino acids or protein-rich natural products. In addition, efforts should be initiated to develop vitamin-C-enriched Pakistani bread by supplementation with dehydrated guava powder, date juice powder and mango powder. This would assist in improving the nutritional status of the people of Pakistan with respect to proteins, vitamins and minerals.

Summary

Pakistan is well-known for the production of many tropical and subtropical fruits. Fruits are important nutritionally but their *per caput* consumption is very low compared to advanced countries. Realizing the importance of fruits in human nutrition, great emphasis was placed in this country for increasing acreage, production and utilization of fruits. The fruit preservation industries were rapidly expanded to conserve surplus fruits for expanding local consumption throughout the year as well as for increasing exports of processed fruits. Although encouraging progress has been made in the setting up of new factories, there still exist some urgent problems which retard the growth and advancement of the Fruit Processing Industry on modern scientific lines. These problems have been classified under following two sub-heads:

1 *Problems for Export*

High costs of raw materials, imported processing equipment, packing containers and inland/ocean freights make the prices of processed products uncompetitive in the International Market and thus impair their position in

importing countries. The Fruit Processing Industries could station marketing specialists in importing countries to give guidance in increasing the exports.

2 *Problems for domestic consumption*

High costs of procurement of raw materials and processing equipment, inadequate marketing procedures and improper location of factories tend to raise the prices of products for home consumption. In addition, poor collaboration between scientists and industrialists, apathy towards trained technologists and inadequate quality control are urgent problems hindering in raising the quality of processed foods.

The dehydration industry is poorly developed owing to lack of investment.

The cold storage industry is facing the difficulties of insulating material, shortage of qualified food engineers and non-availability of proper packing containers for cold storage of fruits and their products. 'Foam-Concrete' and similar locally developed insulating material need to be tried. To meet the need of food engineers, degree courses in this subject should be started locally and till these facilities develop, training facilities in the developed countries must be used. There is a wealth of technical, engineering and nutritional problems awaiting study. These studies, if successful, would be helpful in providing valuable data to be later adopted by the fruit processing industries in West Pakistan.

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Some tropical fruit juices

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Summary

Among the complex collection of fruits, either growing wild or being cultivated in tropical areas, are a relatively small number that are suitable for conversion into liquid materials for ultimate sale throughout the world as intermediate food materials either as juices, concentrates or pulps of various consistencies.

Many of the raw materials suffer from one or another production drawbacks related to some of the following factors: chemical or physical composition; bitterness; abnormally short-ripening periods leading to difficulties in transportation for processing; strong, penetrating flavours which, whilst being acceptable to the local population, are not similarly liked by the consuming public of other countries; lack of availability of specialized plant devised to suit the processing requirements of individual sorts of fruit (as, for example, in the case of citrus).

Reference is made to several fruit juices whose processing or nutritional value include items of special interest at the present time, including miracle fruit (*Synsepalum dulcificum* (Schum) Daniell) from Ghana and other West African countries; camu-camu and acerola cherry from Peru and the Caribbean areas respectively; guava (as a source of vitamin C), mango, papaya, lime, and grenadilla.

General Considerations

The world search for variety in foodstuffs and beverages has been one of the main factors in the increasing number of references to the use of new types of fruits from which to produce new drinks. Some countries, especially the United States, have engaged in an intensive, methodical search for new sources of fruits, leaves, roots, barks, etc. by providing young nutritionally-trained organic chemists with a mobile but extremely efficient laboratory-on-wheels and giving them a brief to peer and poke into every natural material available for analysis in any given area.

In such a way was 'discovered' the camu-camu fruit (*Myrciaria paracensis* Berg) which grows freely along the rivers in the Amazon basin. The fruit competes strongly with acerola (*Malpighia punicifolia L.*) fruit from the Caribbean area. Both fruits showed an ascorbic acid content of about 2,500 mgs/100 g., easily the highest figures known.

On the other hand, there has been an appreciation of the exceptional value from a marketing point of view of raw materials possessing a strong positive flavour and aroma, so that when the degree of dilution dictated by purely economic motives has taken place, there still remains a sufficient intensity of flavour and aroma to gain the appreciation of sufficient consumers to ensure a profitable business.

Of these two fundamental characteristics, nutritive value and flavour, there is nowadays little doubt that the presence of a full, clean, well-balanced flavour is more commercially important than the possession of a high ascorbic acid content. The latter feature can easily be 'imposed' on a low vitamin C juice by the simple addition of the synthetic substance. An idea of twenty years ago that natural vitamin C, *per se,* had some magical quality is not now acceptable. Today the chances of profitable utilization of grenadillas (passion fruit) with ascorbic acid content ranging between only 7 – 70 mgs/100 g., but possessing an extremely potent and attractive flavour, are much greater than those for acerola or camu-camu, with ascorbic acid values around 2,500 mgs/100 g., but with very slight flavour characteristics.

The distinction drawn in the last paragraph between grenadillas and the South American and Caribbean fruits leads to yet another factor in the profitable utilization of natural resources. Some interesting fruits occur in nature in a wild condition, in great variety. The use of such material is hazardous both on flavour and nutritional grounds. The procedure is undoubtedly to produce a clean stock of fruits that are known to thrive in any particular area and then build up planting stock for commerical use that will give reproducible qualities of flavour and chemical analysis. If consideration is given to some of the fruits already mentioned, very considerable divergencies can be seen:–

(a) Wild acerola cherries vary three-fold in their ascorbic acid from different areas, and whilst a new commercial material would obviously be an advantage, it would be extremely expensive to provide.

(b) Camu-camu is quite a rarity so that its growth in newly established plantations in Peru or elsewhere would constitute a major operation which would most probably not engage the financial support of a fruit juice concern.

(c) On the other hand, grenadillas exist only in two main varieties and can be reproduced extremely rapidly in a number of semi-tropical countries.

The advantages at the moment seem to be heavily in favour of the profitable utilization of grenadillas rather than the other two fruits.

Raw material analytical variations

Examples of such variations will be given to show the importance of careful choice of raw material and the search for as reproducible materials as can be found. Table I gives the variations in ascorbic acid in several varieties of guavas.

Table I

Ascorbic acid in several varieties of guava

Sample		**Ascorbic Acid** mg per 100 g.
Florida	Red Cattley	29.1
Florida	Yellow Cattley	39.2
Florida	Common Guava	23.1 – 486.0
Hawaii	Cattley Red or White	25 – 50
Hawaii	Common	96 – 306
California	Common – outer flesh	49.7 – 352.4
Puerto Rico	Common	201.87 – 441.68
India	Country variety	299.0
India	Hill variety	11.0 – 19.1
Australia	Large Yellow	110

Tables II and III give similar information for ascorbic acid in lime juices (Tressler and Joslyn, 1961) from North America and in acerola cherries (Asenjo, 1962) from the Caribbean areas–

Table II

Composition of lime juices

Constituent	*Content per 100 g* *Range*	*Average*
°Brix	8 – 14	10
Anhydrous citric acid	4.9 – 8.3 g	6.0 g
Total sugar (invert)	0.0 – 1.7 g	0.7 g
Non-reducing sugars	0.03 – 0.3 g	0.14 g
Ash	0.25 – 0.4 g	0.35 g
pH	1.7 – 3.2	–
Ascorbic acid	24 – 33 mg	29 mg
Protein	0.3 – 0.7 g	0.4 g

Table III

Ascorbic acid contents of acerola cherries (*M. punicifolia*) from different areas

Country of Origin	*Year*	*Ascorbic acid in fruits described as ripe (mg/100 g. fresh basis)*
Puerto Rico	1946	1,707
Florida	1946	1,996
Venezuela	1950	1,130
Mexico	1951	2,520
”	1955	1,900
Colombia	1957	1,100
Hawaii	1958	2,233

Maturity considerations

If ascorbic acid is considered to be an important constituent in the finally stabilized juice, then the processing of the fruit at the correct stage of maturity must be considered, although the interpretation of this figure in Table IV is not entirely straightforward:–

Table IV

Ascorbic acid in maturing acerola cherries

Age	*Diameter of cherry*	*Colour*	*Ascorbic acid mg/100 g*
7 days after petal fall	2 mm	Green	4,500 – 6,000
14 ” ” ” ”	5 mm	”	4,000
21 ” ” ” ”	8 – 10 mm	Pinky-white	3,500
28 ” ” ” ”	10 – 25 mm	Full red or full yellow or a blend of both	1,300 – 2,500

The extremely high vitamin content of the small ‘button’ cherries does not mean that this is the best stage at which to harvest the fruit to obtain a high return of the vitamin. For example, the increase in diameter of the average cherry from 2 to, say, 15 mm. is associated with a considerable increase in weight which can do much to level out the vitamin recovery per ton of fruit. Again, small green cherries are difficult and expensive to pick and impossible to shake from the trees. Lastly, the juice from immature fruit is either tasteless or definitely bitter, and is difficult to filter.

The final choice of the processor, in collaboration, it is hoped, with the fruit grower, is to produce a course of action which gives the best overall result, considering the use to which the juice is intended to be placed. In normal conditions, it has been found best to harvest the cherries in a very slightly immature condition, thus avoiding the disadvantages connected with under- and over-ripe fruits. It is necessary to determine such compositional changes around the climacteric for each fruit.

Grenadilla (passion fruit) juice

This particular fruit has been chosen for special mention on account of its intense flavour associated with a low ascorbic acid content, and the fact that many methods are currently being employed to popularize its flavour in countries far-removed from the sources of the fruit.

There are two types in common cultivation at the present time

Purple – *Passiflora edulis.* Sims.
Yellow – *Passiflora edulis, var. flavicarpa.* Degener.

The yellow fruit produces larger crops than the other, but the purple is more resistant to disease. The purple fruit juice contains appreciably more ascorbic acid than the yellow, though neither amount is sufficient to use as a real nutritive claim. (Pruthi 1963)

The vines crop very quickly (two years) from planting out and, given adequate support and being planted in frost-free areas where they are known to flourish,

large tonnages can quickly be built up. Over the last thirty years, the centres of activity of growing the fruit have been in Australia, South Africa, Kenya and Hawaii. The juice has been, and still is, mainly used either as an ingredient in a mixed juice drink (i.e. Hawaiian punch or any other form of non-alcoholic punch) or as a straight still or carbonated beverage. The percentage of juice used in the former product may well be quite low (2-5%) but the incorporation even of this small amount can lend some indefinable character to the blended concoction (Kefford and Vickery, 1961). It should not need to be pointed out that the provision of very large quantities of juice may be needed in circumstances where the the punch achieves a break-through sale.

The extraction is done by specially constructed machines devised in Australia and Hawaii; although another quite efficient extractor was designed by a 'trial and error' method by a lone British grower in the Kenyan highlands. It is not *always* necessary to have the services of sophisticated engineering workshops, although they do help!

The death-knell of selling a 'natural' juice in which floated a frog-spawn type of black seed was sounded when the sale of the canned product was extended to European areas from Australia. The sieved product, provided that almost complete removal of starch has occurred in the fruit before harvesting, can be centrifuged free from gross solids but continuing deposits of fine material occurs. The juice has been shown to contain a number of very complicated organic compounds which undoubtedly change their composition as maturity approaches, and these changes need examination before their often adverse effect can be avoided.

Difficult conditions of processing occur in many of the places where grenadillas grow in East Africa, and poor conditions of transport to the coast can often get the juice off to a bad start. One very modern installation in Kenya employs an efficient HTST pasteurizer as soon as the juice is centrifuged or sieved free from seeds, with immediate cooling for packaging and transport. But low temperature alone does not appear to be a complete answer to the loss of character that does occur in juice or concentrate during the transport and subsequent history of the raw material and its various consumable end-products. Only by a thorough examination of the organic constituents and their various interactions during ripening of the fruit and its processing will these instabilities be overcome.

As an example of enlightened enterprise on the part of a European firm of fruit juice producers now operating the Kenyan factory previously mentioned, may be quoted the fact that, without any previous experience of growing fruit, either of European or tropical character, they decided to make a determined attempt to effect a botanical cross between the purple and yellow type of grenadilla, thus combining in one fruit all the advantages and none of the disadvantages of either of the two 'parents'. The overall economics of such a fusion of characteristics may well provide a valuable economic asset to the project.

Acerola

This small tree, known throughout the Caribbean islands as 'the tree of life', is variously known as West Indian, Puerto Rican or Barbados cherry (*Malpighia glabra* L. or *Malpighia punicifolia* L. (Ledin 1958). The fruit had for a long period been regarded in rural areas as having exceptional nutritive and even tonic effects, but it should be said right away that no evidence has yet been found of the presence in the fruit or its juice of any nutritive, physiological or pharmacological effect other than that due to ascorbic acid.

The extremely high content of this vitamin in acerola cherries was first noted in Puerto Rico; and eventually this lead to the distribution to children in a country district of an acerola material to increase their intake of vitamin C. (Asenjo 1962) It is said that the 'acerola queues' attracted the attention of Mr. Harvey Greenspan, a Florida citrus juice magnate, who furthered this benevolent enterprise but was then impressed by the possibility of an ethical development and commercial growing of acerola cherries and their conversion into a raw material for nutritional utilization. Over 1000 acres of specially selected varieties of cherries were set out in a splendid pattern of three plantations, whose sites were chosen to conform to requirements for rainfall, soil composition and facility of transportation of fruit. Working closely with the Puerto Rican Department of Agriculture, these almost certainly unique areas of cherries were developed into an efficient and profitable enterprise.

The acerola fruit is susceptible to frost but, this fact having been allowed for, it remained to choose fairly heavy soils where nematode infections are likely to be less severe and spreading. "Optimum rainfall conditions depend on whether greater emphasis is placed on maximum yields or on fruit size. Heavy rainfalls tend to increase fruit size, and within limits, yields also; but it makes the fruit softer and thus greatly increases their susceptibility to injury during picking and harvesting from the field." (Arostegui and Pennock, 1955). About 70 inches (159 mm) of rainfall a year seems to suit the trees in Puerto Rico.

Eventually a smooth, efficient method of processing was worked out with American food technologists. The main steps of the process are set out below:

(a) The fruit shows the same lowering of ascorbic acid content (Santini, 1953) with advancing maturity (as has already been explained), but it was found best not to harvest the fruit until a decided pink colour had developed. By this time, the fruit had reached approximately 75–80% of its full size. The picking of the trees was a most difficult enterprise on account of the prickly nature of the tree; keeping the centre clear by pruning helped to speed up harvesting.

(b) The fruit was quickly collected in shallow trays or boxes, and was milled in a way that left the stones intact. The juice was removed in a standard type of rack and cloth press (as for apples) and was then roughly clarified and evaporated under vacuum to one-fifth its original volume. The low gravity of the juice (1.040) was not sufficiently high to provide a

self-preserved concentrate, and the only means of stabilizing the product was to freeze it and maintain it in this condition. Any looseness in applying the full low-temperature conditions could lead to loss of character or even microbiological spoilage.

(c) The uncertain storage behaviour of the concentrate led to its ultimate vacuum dehydration on a standard type of band drier. This produced a light-brown porous mass, extremely hygroscopic, but which could be finely powdered in a moisture-free atmosphere and packed into large commercial sized cans. With low temperature storage, the safe life of the canned product, containing dessicant bags, was over twelve months. The main interest in this powdered product centred around its very high ascorbic acid content; whilst the average content was 30% w/w, appreciable amounts were prepared at 35%, and some powders reached as high as 38%.

Concentrates stored at freezing point were also widely distributed from Puerto Rico to East Coast areas in the USA where direct shipping lines were available.

The acerola powder has many uses. It can be diluted to juice and made into sucrose-syrups with guaranteed ascorbic acid contents for children or, more recently into sucrose-free syrups (but containing glucose solids) which are highly acceptable to the dental authorities in view of the caries-forming potentialities of sucrose. The powder is an acceptable raw material to introduce into high vitamin C level powdered health product with multiple vitamin content.

(d) The preceding paragraphs have shown the development of an attractive process for a nutritive material of high value from a semi-tropical fruit crop. The powder was in demand from many pharmaceutical and beverage firms in the USA and from most large countries in Western Europe. However, in 1967, the acerola producing company was overcome by the situation of complete inability to harvest the crop of cherries. The agricultural and horticultural labour situation on the island became acute as more and more land workers withdrew their services and moved to the large seaside resorts where superior wages were obtained with the utmost ease. Despite making every effort to solve the problem, such as automatic shakers to attach to the main branches of the trees, the plantation had to be left unharvested and it seems at the time of writing that this will mark the (temporary?) end of an exhilarating experiment in fruit juice techniques. The cessation of production obviously leaves some 'vacuum' in the supply position, but it is hoped that this can be filled without too much delay; (Anon, 1961).

Miracle fruit

Rather as an example of a fruit curiosity than a current commercial success, a brief reference is made here to the discovery in 1964 of the reputed power of the fruit of a small bush, Miracle Fruit (*Synsepalum dulcificum* (Schum) Daniell) of 'inactivating' all acid-orientated taste buds in human beings. For example, lemon juice, tasted after coating the interior of the mouth with the broken fruit or its juice, is said to lose entirely its acid taste but to retain its full fruit character. (Inglett *et al* 1965)

This example of a fruit material possessing a definitive physiological action in human beings may not have any obvious commercial application at the present time; but such new knowledge of any potentialities of fruit products must be expected to arise from time to time as a result of a systematic examination of the natural fruits of various areas, thus emphasizing the fundamental value of a continuing examination of natural fruit material wherever they may occur.

Guava, mango and papaya products

The processing of these fruits is well-established and covered by a reasonably wide literature.

(a) *Guava (Psidium guajava L.)* This fruit is one of the select group that can show a high ascorbic acid content simultaneously with an intense and attractive (to some people) flavour. People who habitually eat guava appreciate the luscious flavour of the juice, but the inverse proposition unfortunately is true also.

Apart from the simplest procedures, the fruit in South Africa is sometimes milled to a coarse pulp, heated to 37°C.–43°C., and treated with a pectinase enzyme at 0.1–0.2% for twelve hours. With an efficient breakdown of pectin, the resulting pulp can be pressed to provide a cloudy juice at 75% yield. From this a syrup can be produced and will retain its natural flavour at freezing point or just above for up to two years (Burger 1960). At ambient temperatures, only one year's shelf-life is obtained. The clarified juice can also be concentrated in vacuum up to 65° Brix. Levels of ascorbic acid up to 2,500 mgs/100 g. can be reached, but such concentrates must be stored at freezing point if development of high pressures of gas in the cans due to decomposition of ascorbic acid is to be avoided. (Anon, 1957)

(b) *Mango (Mangifera indica L.)* Clear juices are not produced, but the commercial products today are in the form of nectars or very cloudy juices (Kay, 1966). Squashes made from juices are popular in India, whilst South Africa and Puerto Rico make extensive use of this fruit for a variety of canned and bottled beverages. No interesting vitamin C story is involved. (Sanchez-Nieva, Rodriguez and Benero, 1949).

(c) *Papaya or Paw-Paw (Carica papaya L.)* This fruit is widely grown in all tropical and semi-tropical areas, and is processed into nectars containing about 40–60% fruit materials and other tissue-containing types of beverages either for dilution or straight consumption. (Anon, 1963)

There is a current interest in lime juice production. To some extent it is due to a new appreciation of the lime flavour (both from juice and essential oil) on the part of many juice, beverage and essential oil blenders in Europe. The continuance of such a trend could well cause a shortage of fruit, and in this connection it is well for intending producers in lime-growing areas to remember that the economics of lime products nowadays virtually demand the production both of juice and oil from the same fruit. To leave out one or the other end-product is to court financial loss.

For juice products in Europe, the small West Indian (Key or Mexican) lime is much preferred to the Persian (Tahiti) fruit, which grows mainly in Florida and is much larger, being oval and the size of a small lemon.

The economical processing of the fruit into juice and cold-pressed or distilled oil varies from year to year according to current price for these two commodities and years of experience are needed to obtain with reasonable certainty the best returns. (Anon, 1962)

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See also:—

Technical papers and statistical tables of the 1st Pacific Rim Food Conference (1960): Hawaiian Section, Institute of Food Technology.

Discussion

Mr. Dalton: To what extent is the growth of the private sector in the canning industry in Ceylon being financed locally and to what extent is foreign capital participating, so far?

Mr. Alles: So far, the private sector industries that are coming up are financed entirely from local funds. They are being assisted by various banks and are also being given assistance as I have indicated by tax concessions, foreign exchange availability by government, etc.

Dr. Sinnadurai: In Ghana there are several local canning industries, serving a population of only 8 million. How far does locally processed products compete with those from abroad, and how much internal competition is there.

Mrs. Ocloo: We have three canneries belonging to the Government and one to a private enterprise so far. There is no control of importation of the products being made, so competition is very keen. There is a plan to control importation of citrus products and jams and marmalade. If this was put into effect, I think the canneries we have so far would make money. Also, I am trying to produce specialities where there is no competition at the moment. I hope that I will be able to market these not only locally but also in Europe, where people are becoming increasingly interested in unusual products.

Miss Oliver: In demonstrating the effect of fruit variety on ascorbic acid content of acerola, the varietal samples were tested in different years and the possibility of interference due to seasonal effect cannot, therefore, be ignored. Seasonal fluctuation in average ascorbic acid content of fruits could create significant problems in production control when packing to standard vitamin content, as Dr. Charley and I found during the first year of implementing the Ministry of Food Scheme in the Second World War, whereby blackcurrants were used to supply British children with vitamin C. In this year the average value fell to 150 mg per 100 g. fruit compared with figures of around 200 mg per 100 g. fruit in all preceding years for which records were available.

Mr. F. J. Hall: Dr. Siddappa mentioned the possibility of extracting by-products of banana, mainly starch and fibres. This is technically interesting. I should like to know whether any data on the economics of extraction are available. These by-products are present in small proportions, and the economics may well be more important than the technical problems.

Dr. Siddappa: Studies show that it would be feasible to extract starch and fibre together after utilizing the fruit. A small pilot plant is working in India which extracts the starch and the fibre.

Dr. Godfrey-Sam-Aggrey: In view of the fact that the Miracle Berry will give analgesia, I want to know what will be the chances of this fruit making a lasting and consistent impact in the European markets? In the United States this fruit is a curiosity. I want to know what its chances are, commercially.

Dr. Charley: We have made a quantity of miracle fruit juice. It is true that when you take a miracle fruit into your mouth, there is an effect of blocking out the acid taste buds. This we believe is caused by a glucoprotein. We have found that to have this material analysed and prepared synthetically would be too big a venture altogether. There is no nutritional value in it. Our own view is that there is nothing foreseeable for the use of this fruit to make a juice for any purpose which is currently envisaged. I think it has no real practical potential.

Dr. Pansiot: The FAO has received requests from a United States food company regarding miracle fruit. The main purpose of these requests was how to get sufficient quantities to start an industrial plant for the preparation of low calorie ice-creams. Adding this juice

to a non-sweetened flavoured juice, would give the impression that it is sweet. Ice-cream without sugar could have a few drops of this sweetener added, to give an ice-cream of low calorie content. We have had difficulty in locating African plantations. The producers we found in Ghana were scattered and were unable to produce enough for exportation.

Dr. Maliphant: I have noted the existence of the Miracle Berry as a hedgerow, in Guyana. It might be worthwhile to go outside Africa to locate it.

Dr. Charley: Concerning Pakistan, I have one suggestion that could be of marginal help to the industry there. Could the fruit processing industry approach the Government for legislation favourable to its development, for example, relief of import duty on capital equipment, or drawback of duty on imported packaging material?

Mr. Bhatti: In Pakistan, from the export angle, steps to help industrialists have been taken. There is an export corporation and export houses to help industrialists with various problems.

Sixth Session

Wednesday 17th September
Afternoon

Chairman
Dr L. W. Mapson, FRS
Food Research Institute, Norwich

The Windward Islands banana industry

C. A. Phillips and J. Spector
Windward Islands Banana Research Scheme, St. Lucia, West Indies

Summary

(a) In the immediate post-war years, the United Kingdom market was undersupplied with bananas.

The Windward Islands banana industry was virtually created to satisfy the demand of this market and has expanded continuously. Exports have risen from 56,000 tons of fruit in 1957 to over 188,000 tons in 1968.

The expansion of the industry followed the regular arrivals of modern refrigerated ships and the development of a highly integrated marketing structure.

The Windward Islands Banana Growers' Association (WINBAN) was formed initially to provide hurricane insurance for the crop and to protect the growers' interests.

It was also responsible for the establishment of the Research Scheme which embraced problems associated with increasing the yield per acre, studies of new varieties and improvement of quality.

(b) Fruit quality, which follows a seasonal pattern, has shown a steady decline since 1961.

The deterioration could have been due to any or all of four main factors, viz: (a) improper handling of the fruit (b) increased fungal activity (c) inadequate plant nutrition (d) higher grading standards employed by the marketing agents.

Improved handling techniques aimed at providing greater protection to the fruit are presently being introduced to the islands.

The bulk of the Windward Islands' fruit is shipped on the stem because trials with box-packaging have been unsatisfactory in the past. However, recent fruit box trials using thiabendazole fungicide treatments have given very encouraging results. With continued success with this compound and if its use on export fruit is permitted, it is estimated that the Windwards will convert fully to box-packaging of bananas within three years.

Prior to 1939, Jamaica was the traditional supplier of bananas to the United Kingdom and exports from the Windward Islands, comprising the territories of Grenada, St. Vincent, St. Lucia, were insignificant. In post-war years, the UK market was under-supplied, and the Jamaican industry was slow to recover. The banana industry in the Windwards was virtually created to fill the gap.

Expansion was inhibited in the initial phases due to lack of suitable shipping opportunities. Bananas are among the world's most perishable crops. They need to be shipped in temperature controlled vessels, and harvesting must be co-ordinated with the arrival of ships so that these can be loaded to capacity. After arrival at the port of destination, the banana has to be ripened and distributed within a limited time.

In 1954, Geest Industries Ltd. entered into an agreement with the various Windward Island associations. This organization offered regular arrivals of modern refrigerated vessels, a highly integrated marketing structure and a contract to purchase all of the bananas of export standard that the islands could produce.

The contract reached with Geest Industries allowed for deductions for freight and marketing expenses, and included a formula under which a quality premium was payable and provision was made for participation in ripening profits. Since the trade in the United Kingdom follows a seasonal pattern, an incentive bonus was included to encourage production in the summer months (i.e. 1st April - 31st September).

Other factors also favoured the development of the industry. The short period of maturation of the crop meant that income was generated regularly and frequently. This appeals to the small-holder and over 90% of the farms are cultivated by "mini" growers. To date, there are nearly 32,000 growers registered with the associations. In order to assist the initial establishment of the industry, loans were made available by such agencies as the Commonwealth Development and Welfare scheme and the commercial banks.

To aid administration and represent interests in general, the various island associations formed an overall organization—the Windward Islands Banana Growers Association

(WINBAN). Two of its main tasks were to set up a hurricane damage insurance scheme; and establish the WINBAN Research Scheme to investigate the cultivation and husbandry of the crop (Spector, 1965; Twyford, 1965).

The success of the venture is reflected by banana imports into the UK. In 1954, 19,700 tons were imported from the Windwards: in 1968 the figure exceeded 178,000 long tons, nearly a nine-fold increase. In 1968, for the first time, exports from the Windwards exceeded those from Jamaica by some 29,000 tons and they are now the largest supplier to the UK.

Unlike Italy and France, the UK imposes no price control or quota restrictions on banana imports, other than those originating in dollar areas. Returns are based on the 'green boat price' which fluctuates widely with market conditions. Bananas from Commonwealth areas enter duty free, those from other areas are subject to a duty of £7.10.0. per ton. The effects of inflation and devaluation have over the years diminished the protective value of this fixed tariff.

The banana industry accounts for the main export earnings in the Windwards. Clearly, any variation in the UK's import regime would be of vital concern to these islands. The position respecting the Windwards Banana industry, should Britain join the European Economic Community, has been studied elsewhere (Spector, 1967).

Marketing

In contrast to the Continent, where the consumption of bananas has risen considerably since the war, consumption in Great Britain has remained static at just over 6 kg. per caput per annum. Experience has shown that a depression of retail prices does not increase consumption.

It is possible that consumption could be increased by promotional methods but before such activities could be undertaken it would be necessary to ensure that sufficient high quality fruit was available.

Conversion to boxing can increase the amount of quality fruit. In the Windwards, early experiments in boxing proved disappointing and stem shipments are still made. However, current experiments are showing promise and should they prove successful on a commercial scale, they will no doubt be adopted.

The shipping of fruit by Geest Industries is highly organized. They operate a fleet of refrigerated ships the newest of which can carry some 200,000 stems. Containerization has recently been introduced, reducing the number of handling operations. After arrival, the fruit is carried from the docks by large insulated vans each holding 1,000 stems. At the depots, the fruit is taken to ripening rooms, each of which can accommodate some 750 stems.

The ripening period can be controlled between 4 to 10 days by varying the temperature, humidity and ventilation, and the use of ethylene in appropriate concentrations. The ripening rate is adjusted in accordance with market requirements. After ripening the stems are passed to the cutting section for de-stemming and grading.

In 1967, the question of international quality standards for bananas was raised by Czechoslovakia with the Codex Alimentarius Commission. It is difficult to lay down such standards since there are regional differences in importer requirements. The trade sets its standards and the exporters must produce and handle fruit to meet these standards. Market research has shown that the United Kingdom consumer prefers clusters of approximately four to the pound weight. Robusta has proven more acceptable than the larger Gross Michel. Preference is based on appearance rather than flavour and bananas which command the highest price are normally free from any blemish with a green tip. Total sugars range from 10-18% and starch from 10.5-2.5%.

The advent of the supermarket systems has resulted in the introduction of 'pre-priced' bananas. These are clusters of top grade fruit conforming with the above standards that are weighted and priced for the supermarket chains.

Geest Industries have five grades which when packed into boxes are wrapped in coloured paper. The colours serve to denote the grades which are: 'Specially Selected', 'Mauves' (Best), 'Blues' (Seconds), 'Whites' (Thirds) and 'Pinks' (Loose). 'Specials' and 'Mauves' are top quality grades consisting of good length fruit, free from fungal rots and blemishes. Shorter fingers, minor skin blemishes and negligible to slight fungal rot characterize the 'Blues', while 'Whites' and 'Pinks' are low quality fruit exhibiting moderate to severe fungal decay.

Unfortunately, increased exports from the Windwards have not been accompanied by similar increases in the outturn of top quality ripe fruit in the United Kingdom, as shown in Figure 1.

Prior to 1961, the percentage outturn of 'Specials' and 'Mauves' increased annually, reaching a peak of 70.8%. Thereafter the proportion of top quality fruit has been declining steadily with the lowest level to date being 35.0% in 1968: see Figure 2. Conversely outturns of 'Blues', 'Whites' and 'Pinks' have progressively increased. However, outturn increases of 'Blues' were greater than of 'Whites' and 'Pinks', indicating higher grading standards in the market as a cause of decline in quality rather than effect of increased fungal decay. Both 'Specials' and 'Mauves' and 'Whites' and 'Pinks' outturns respectively have decreased in 1968 compared with those of 1967, but production of 'Blues' has increased markedly.

Effect of Season of Fruit Quality

In the Windward Islands there are two distinct seasons: a relatively cool, dry period from January to June and a hot spell from July to December. Averages of monthly rainfall and the daily maximum temperatures recorded in St. Lucia and the mean monthly outturn of 'Specials' and 'Mauves', 'Blues' and 'Whites' respectively were determined for the period 1966 to 1968. When quality outturn data are plotted against rainfall and temperature respectively, a definite seasonal pattern in fruit quality outturn

appears see Figure 3. The percentage outturn of 'Whites' declined during the cool dry season and increased in the hot, wet months. Conversely, 'Specials' and 'Mauves' outturn increased in the dry season and fell during the wet. Outturn for 'Blues' seemed not to follow a distinct seasonal pattern.

Fruits maturing in the wet season are softer than those of the dry and are more liable to mechanical injury and subsequent fungal infection. The high temperatures prevailing during the wet season tend to hasten maturity leading to increased fungal decay both in the field and during storage and ripening.

Effect of Fruit Rot Fungi

Increased fungal activity could be partly responsible for the deterioration in quality of Windward Islands' bananas. Work on the nature of rot-producing fungi in bananas has been conducted in the Caribbean and elsewhere (Meredith, 1960; Wardlaw, 1961; Green and Goos, 1963). To date, only a very preliminary identification of fungi causing rot in Windward Islands' fruit has been made. In this study, three primary pathogens along with other fungi associated with fruit rot were isolated, including *Gloeosporium musarum* (Cooke and Massee) three *Fusarium* spp. and *Botryodiplodia theobromae* (Pat.) However, much more work is required.

Effect of Sigatoka Disease on Fruit Quality

The bananas grown in the Windward Islands are mainly 'Robusta' and 'Lacatan' which are very susceptible to leaf spot or Sigatoka disease caused by *Mycosphaerella musicola* (Leach). Fungistatic mineral oil applied as a mist is used for controlling the disease. The incidence of 'Sigatoka' in the Windward Islands has been very high especially during the wet season, due mainly to the ineffectiveness of the oil used. Losses of fruit production and quality due to the ravages of 'Sigatoka' must have been considerable. However, there is no evidence that the incidence of leaf spot has increased over the period and contributed to the decline in fruit quality.

Agronomic Factors affecting Fruit Quality

Bananas from the Windward Islands are shipped as stems (bunches) wrapped in paper and polythene. Fruits thus packaged are very susceptible to finger-dropping, one of the commonest causes of fruit loss in banana handling. Bananas vulnerable to finger-drop show a mechanical weakness, caused by a narrow, elongated pedicel and this pericarp. Guillemot and Golmet-Daage (1965) reported a close relationship between the pedicel ratio (i.e. pedicel length divided by width) and the liability to finger-drop and invasion by fungi. They stated that finger-drop was promoted by sharp variations in the available soil nitrogen, especially those exceeding a critical value of 10 ppm. They concluded that soil nitrogen should be kept as high as possible during the critical period following the first heavy rains, and applications of nitrogen avoided at the end of the dry season when the soil nitrogen was very high. In the Windwards, the tendency is to apply fertilizers at the onset of the rains and this may promote finger-dropping and a deterioration in fruit quality.

During the early 1960's, the practice was to grow bananas in the Windward Islands at densities 3,000 mats per hectare and higher. Bunches from very high density plantings, when followed through to the ripening room were reported to give rather poor outturn. The association of quality deterioration with high density may be due to several factors. Phillips (1967) found that high densities produced softer fruits than low ones and also had an adverse effect on the pedicel ratio at high rates of fertilization. The pedicel ratio also increased with rates of fertilization.

It is suspected that some nutrient elements, notably sulphur and boron may be also causing deterioration in fruit quality in the Windward Islands. Twyford (Private communication) stated that fruits from plants fertilized with potassium sulphate were of superior quality to those plants fertilized with potassium chloride. Though it is not clear whether such results are due to overcoming sulphur deficiency or to avoiding adverse effects of chloride or both, such results suggest that those elements may play a role in fruit quality. Further, Messing (1969) reported that many Windward Islands' soils were deficient in sulphur which appeared to be strongly affecting plant growth and fruit quality. This is supported by the fact that over the past few years the fertilizer used in the Windward Islands consisted of N, P, K and Cl only. Deficiency of sulphur and other nutrient elements may be developing by soil depletion with consequent adverse effects on fruit quality.

Effects of Fruit Maturity on Fruit Quality

The grade of fullness of the fruit at which bananas are harvested for shipment affects the fruit quality outturn at the marketing end. In general, the grade at which bunches are cut depends mainly on the distance from the market and to some extent on the clone and on the ecological conditions. The longer the period of transport, the less mature it is harvested. From Grenada, the furthest island in the Windwards, the fruit takes about 14 days from harvesting to arriving at the ripening depot and the recommended cutting grade is '¾ full', judged by the eye on the angularity of the fingers. Such a subjective method of grading fruit gives rise to a very wide variation in the maturity of the fruit harvested. A survey of the grades of fruit accepted by the marketing agents in St. Lucia indicated that the diameter of an index 'finger' ranged from 28mm to 36mm. Fruits may be more mature than they appear to be and so behave abnormally during transport and subsequent ripening. It is felt that a more precise method of grading, using

calipers or gauges, would result in improved quality outturn due to much better uniformity.

Post-harvest injury to fruit

There is no doubt that imperfect handling of the fruit after harvesting results in heavy losses in quality. Further, the roads in the islands are extremely rough and quality deterioration during local transport must be relatively high. Bunches fit for harvesting are cut and carried from the field to the shed where they are wrapped in wadding paper and polythene tubing for shipment. Little or no protection against mechanical damage is given to the fruit before it is wrapped: at best bunches are wrapped in moistened banana straw. Williams and Twyford (1966) reported that losses in fruit quality were high at the pre-wrapping stage, while moderate and small losses were experienced during trucking and shipping respectively. Twyford and Mason (1967) later found that the use of padded trays, especially those holding three bunches, for carrying fruit from the field to the wrapping shed gave better quality outturn than the traditional method of carrying two bunches on the head. The findings above are not surprising for most of the damage done by fungi is a direct consequence of mechanical injury to the fruit during harvesting, handling and transport.

Techniques aimed at improving fruit quality

Efforts are being made to implement new techniques aimed at improving the quality of Windward Islands' bananas. Planting densities lower than those previously employed are now being advocated and balanced NPK fertilizers including sulphur are now applied. Farmers are encouraged to pay closer attention to the developing bunch by the use of polythene bunch covers and the removal of the male flower and small hands: such practice should improve finger length and minimize skin blemishes. Post harvest innovations include the elimination of banana straw as padding material in favour of plastic foam. Bananas wrapped in foam sheets immediately after harvesting are carried on foam padded trays to the wrapping shed. At the sheds, bunches are laid on foam mats and when stacked are separated from neighbouring fruits by foam sheet. Vehicles employed in transporting wrapped fruits to the reception depot are also completely foam padded. These improved bunch handling techniques are being made compulsory by legislation.

Probably the most important innovation now being introduced is the conversion to box-packaging of hands. There are many advantages accruing from box-packaging (Simmonds, 1966; Cadillat, 1962). However, at the present time, most Windward Islands' bananas are exported to the UK as 'stems' wrapped in paper and polythene. The results of numerous boxing trials in the past have been disappointing due to decay and attempts to control this decay with Maneb and other materials have been unsatisfactory. In recent trials, Thiabendazole (TBZ) has been extremely effective in arresting fruit decay (Phillips, 1969). Clearance for its use on bananas has already been given in the USA, Canada, West Germany and Australia and approval in the UK is being sought. As a result of this success with TBZ, plans are now afoot to ship 25%, 50% and 100% of the fruit exported in cardboard cartons by the end of 1969, 1970 and 1971 respectively.

Because of the importance of improving fruit quality several further compounds are presently being tested and compared at the WINBAN research laboratory. In preliminary boxing trials, the fungicide Benlate or DuPont 1991 has given very encouraging results. However, more toxicological data on this product is required before it could be utilized in shipment trials.

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Figure 1

Annual export production in relation to 'Specials' and 'Mauves' out-turn in the UK for period 1959 to 1968

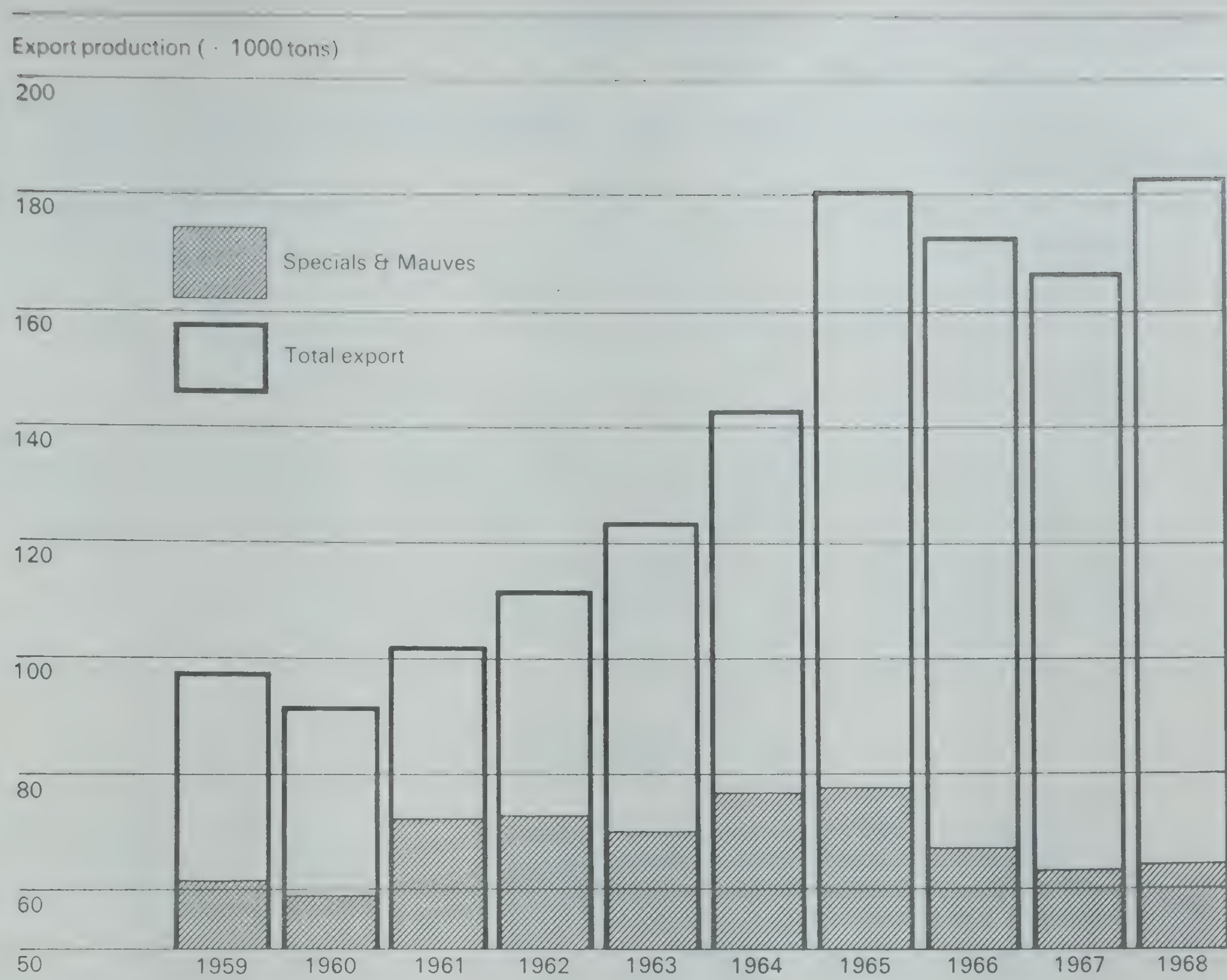


Figure 2

Annual fruit quality out-turn for period 1959 to 1968 (Data on 'Blue', 'White' and 'Pink' for 1959 to 1962 unavailable)

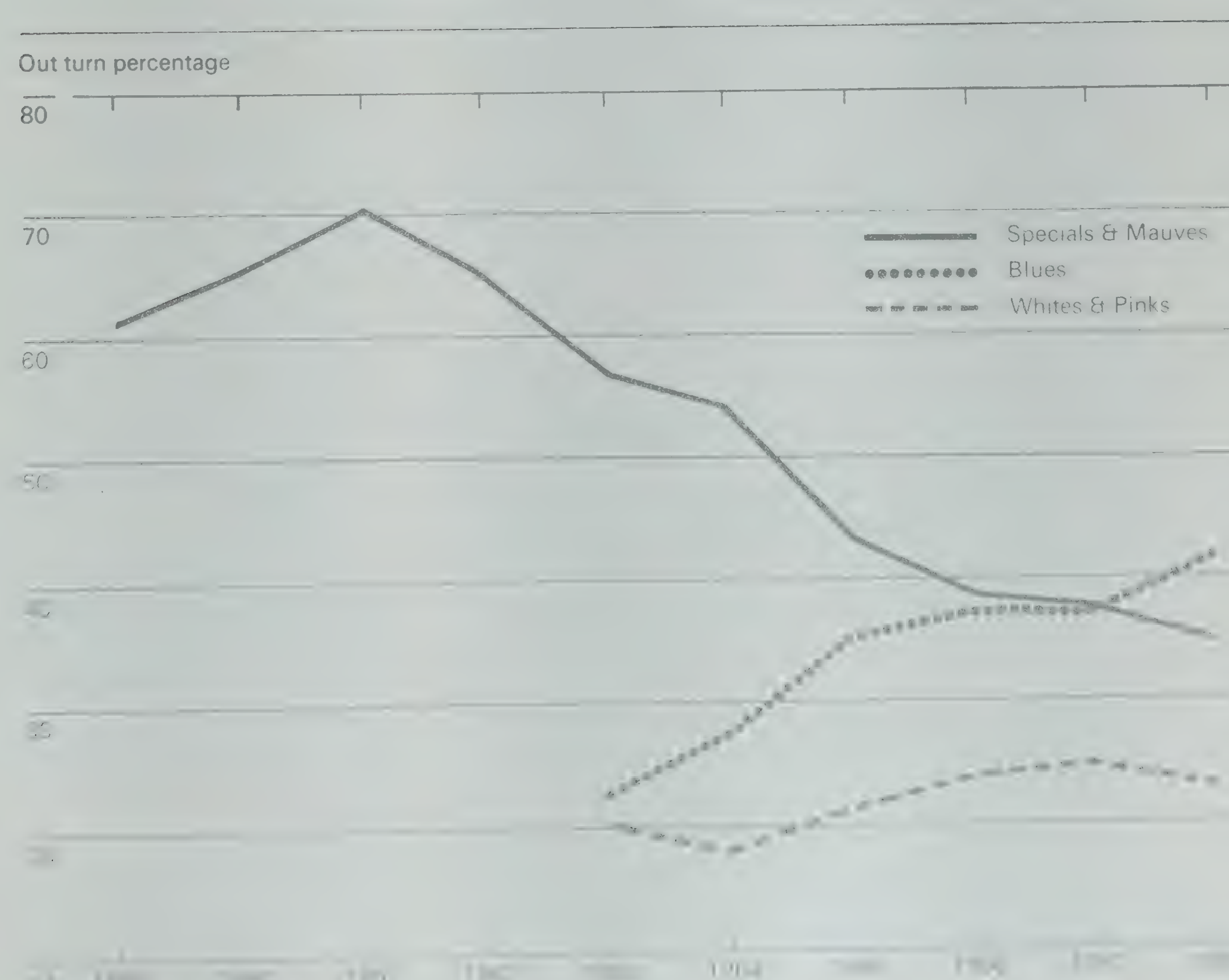
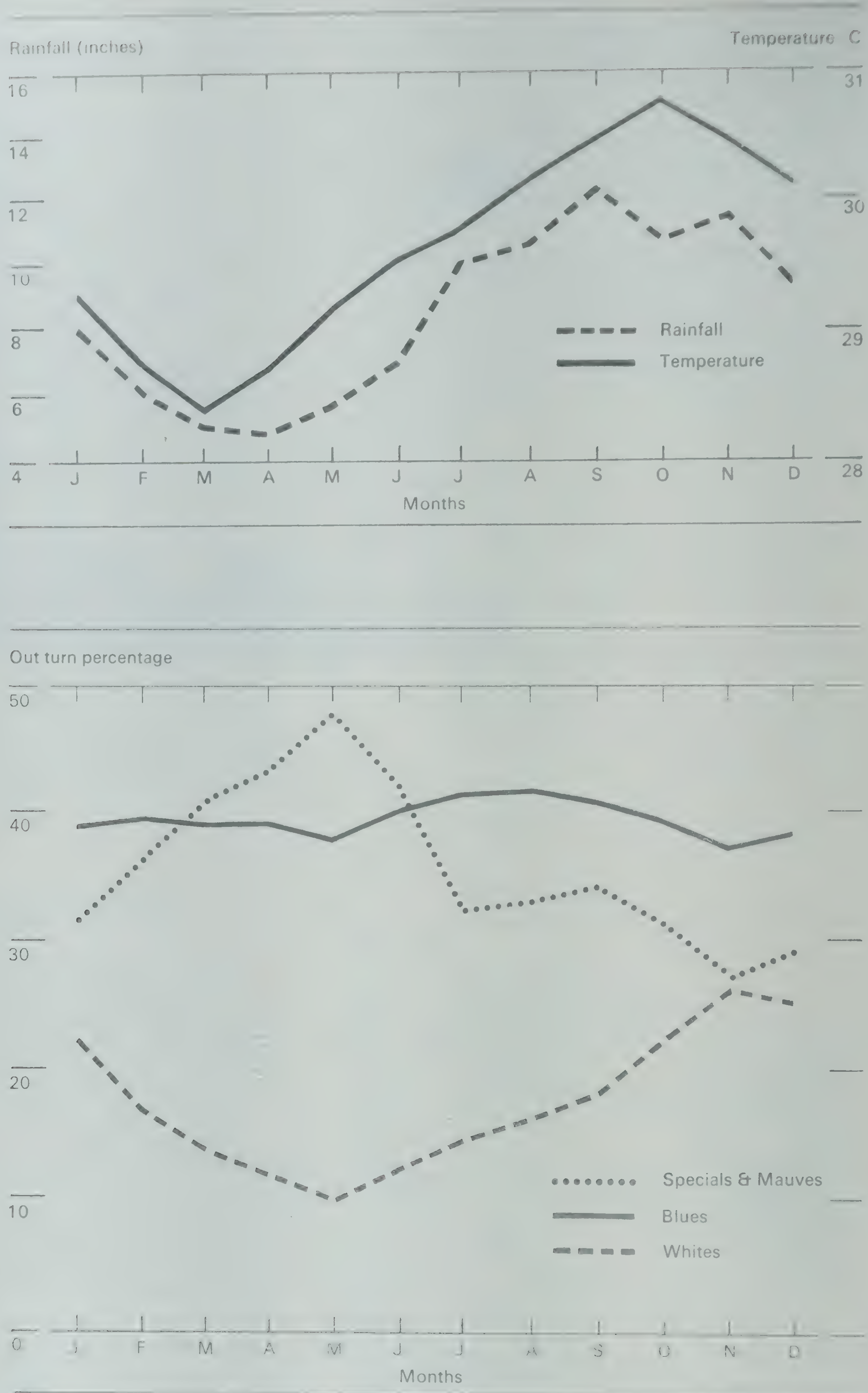


Figure 3

Effect of rainfall and temperature on average monthly fruit quality out-turn for period 1966 to 1968



The scope for development of food processing industry in Dominica

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Summary

The agricultural sector of Dominica (including farm, market, agri-business and agri-services) is of strategic importance for economic growth and development. It contributes the largest share of the gross domestic product and employs the major proportion of the economic resources of the territory. Dominica produces an abundant supply of certain food items, including subsistence crops. Surpluses of farm products exist because of limited markets, high perishability and inadequate transportation arrangements and the lack of knowledge in marketing techniques.

The establishment of a food processing industry to handle these farm products is advanced as an essential adjunct for the development of the agricultural sector, with spill-over effects into other vital sectors of the economy.

A feasibility study as the conventional approach to determine economic justification for implementation of such a project is inapplicable. Decision making must be based on social cost/benefit analysis.

The issues are clearly in the direction of the externality effects which would increase existing low levels of activity in agriculture in terms of available land resources and reduce relatively high per unit costs of production.

The quantum of available farm supplies for processing is small but can be increased within the cultivable land resources. Demand for these processed goods has not been estimated but preferences for acid-flavoured and sweet-flavoured tropical fruits, root crop dishes and vegetables exist in the Metropolitan and West Indian oriented markets respectively.

By public intervention a food processing industry, operating with a flexible multiple processing pilot plant, can thrive economically, from development to commercial stage, through exploration of demand for the final products which in turn creates demand for farm supplies, to be stimulated by specific public agricultural programmes.

Introduction

Agriculture has to be taken as the crucial sector of the economy of Dominica. It is by far the largest sector, the most developed – one which provides employment for the majority of the people either directly or indirectly, and contributes the largest share of the gross domestic product. It consists of export agriculture and other agriculture, the latter being mainly imputed value of foods consumed on the farm.

The growth of the economy has been generated by the expansion of export trade, dominated by agricultural products. Export agriculture therefore has been the key component of economic activity and growth. This growing point of productive activity which is essential to achieve the income goals demanded by the aspiration of the Government and people of Dominica has been adversely affected, in the course of time, by the instability of the price structure for these particular export crops. These cash crops, excluding bananas which contribute approximately eighty per cent of total exports, are tree crops. These include grapefruit, orange, coconut, cocoa, bay leaf and condiments. These tree crops enter economic production after a period of five years which constitutes the establishment and initial development phases of the crop.

Despite market and agronomic risks, export agriculture has maintained its relative position. Domestic agriculture which produces food, mainly carbohydrate root crops, and some vegetables and fruits for the home market has been confined to the traditional system of small scale farming and is not expanding significantly. In fact, there is evidence that fruit trees are being cut down to give way to banana and grapefruit production – the existing economic export crops.

The production of banana is attractive to the small scale farmer because it is labour intensive and provides regular wage income. These farmers occupy approximately 46 per cent of present land resources of Dominica which is held as farmland. Grapefruit is presently a high net return crop and large scale farmers are attracted to enter into economic production of this crop and to expand existing acreages.

The argument for the establishment of facilities to produce certain farm products of Dominica in the processed form is based on the fact that there is an abudant supply of certain food items on the land. This does not take into account the surplus production of grapefruit and oranges. The volume of surpluses of these market crops is unstable since farm products entering the fresh fruit trade fetch higher prices than those entering a manufacturing industry. Consequently if opportunities for market disposal of fresh grapefruits and fresh oranges tend to change from time to time then there will be fluctuations in the volume of surpluses of these fruits. A food processing industry for Dominica therefore cannot be based on the dependency surpluses of these fruits. It must be based on stable supplies of farm products which depend either on the industry as their principal market or are subject to a quota allocation arrangement between the fresh food market and the processing industry.

The seasonal production of these farm products makes them subject to market gluts and shortages which are reflected in the undesirably fluctuating prices to which farmers are exposed.

Export demand for these products exists in the metropolitan markets mainly, but transport arrangements are inadequate for successful trading. These farm products, in the fresh form are highly perishable. If processed however, they can be stored to take advantage of whatever shipping opportunities may exist.

It is argued further that the supply of a wide range of these processed goods as differentiated products would increase the overall demand for the total potential output of a food processing industry, and as a consequence, would generate a stable increase in the demand for the food products.

The Concept on which the establishment of a Food Processing Industry should be based.

It is important at the outset to establish the concept on which the establishment and operation of a food processing industry should be based in Dominica. This would provide the essential framework for planning and financing.

The conventional approach which is used to determine whether there is economic justification for implementation of a project of this nature is based on private cost/benefit analysis.

The questions which must be answered are whether supplies of raw material are available to the plant at prices which farmers are willing to sell and which a growing industry can afford to buy so that the plant can operate for at least 300 days per year; and whether the products of the industry can find a ready, stable and profitable market at home and abroad. This assumes however that capital, technology and appropriate areas of infrastructure are available for the establishment and development of the Industry.

In the conventional way of thinking, the results of such a feasibility study would induce the entry of private capital to undertake the investment project. Since the development of agriculture which is the basic growing point of the economy of Dominica is of major public concern, then the inducement of private capital into such a project is not the crucial issue for decision making on the subject of the establishment and operation of a food processing industry.

The issues to be considered are clearly in the direction of the externality effects of such a project in increasing the level of activity in the agriculture of Dominica, at present relatively low in terms of the available land resources, income levels and employment and the possibilities of reduction of unit costs of production, which is increasing all the time, by intensive agriculture.

The supply and the knowledge of a product can generate demand which in turn generates further supplies. Since the supply of existing farm products could be mobilized through attractive farm prices built up either through a public price support programme or indirectly through the allocation of shares to farmers as an added incentive in order that they may sell their products to a food processing industry, with a potential of idle but suitable lands in Dominica, a feasibility study with a term of reference as outlined to determine the merit of such a project is considered inappropriate. The public sector, it is argued, must take the initiative to set up the Industry to the viable stage.

In the light of the foregoing therefore, the points of importance for analysis of the scope for the development of a food processing industry in Dominica are listed as set out below.

(i) The possibility of generating supplies of farm products for processing the quantities to accommodate an efficiently operating processing plant at some specified point in time after initial establishment and the availability of markets to absorb the finished products at a price and in quantities that will pay the farmers to produce the crops for the Industry.

(ii) The availability of public capital and technical skills for the establishment and operation of such a plant during the development stage of the project.

(iii) The conscious effort of the Government to influence the use of resources and the level of investment for economic production of these crops according to the demand, through specified agricultural incentive programmes, supervised agricultural credit and agricultural extension programmes.

Before discussion of the second part of this paper which will deal with the analysis of the situation, it is useful to define the term *food processing industry*. In this context, I restrict the definition to mean a firm or group of firms engaged in the production of particular goods made from farm products which are sold on the market in precooked packages, canned, frozen and dried forms. These goods are final products for consumption as part of the daily food intake of people.

The analysis of the situation

(i) *The possibility of generating supplies to support the operation of an efficient processing plant at some specified point in time after initial establishment and the availability of markets to absorb the finished products at a price and in quantities that will pay the farmers to produce the crops for the Industry.*

At the outset it is important to examine the volume of supplies that is available for the operation of any food processing plant. Careful consideration must be given to the types of farm products which are available for processing, the suitability of the many varieties of these products for processing, consumer tastes and preferences for these products, and then volume, calculated on an acreage and yield per acre basis dependent on these factors.

With this information on hand, an estimate of the potential supply of farm products for processing can be attempted. This estimate must be based on the acreage of farm products which are expected to come into economic production, together with acreages of farm lands and public lands which are either idle or in production of low market status crops, and which can be bought into profitable production of these crops in the mean time.

The types of farm products which are produced and which can be utilized as raw material for any food processing industry fall into the following broad categories.

These farm products for which there is a regional export demand, but with limitations imposed on the volume of supplies to these markets by inadequate shipping arrangements and high freight costs, for example, in the case of oranges.

Those farm products which are produced mainly for consumption on the farm but in some cases these are sold on the local and/or regional market in limited quantities because of relatively low demand for these products. These crops are produced with negligible attention. Sometimes they grow in the wild state and are generally produced from haphazard planting patterns. In many cases these tree crops were established as shade trees and windbreaks. This refers to such tree crops as the mango, soursop, guava, tamarind, pomerac, custard apple, sugar apple, plums, gooseberry and mangosteen.

Those farm products which are produced for the local market but supply is in excess of demand. This refers particularly to cucumbers.

Those farm products which fetch a high price during a specified market period of the metropolitan fresh fruit trade, but this market period of short supply is of limited duration. Increasing supplies from production in Dominica and other competitive sources such as Israel are likely to affect farm prices in Dominica adversely. This refers to fresh grapefruits.

Those farm products for which there is an export demand in the fresh form on the metropolitan markets but the high degree of perishability of these products restrict trade because of the unduly long storage period required between field harvest and final market acceptance. This is as a result of shipping difficulties and inadequacy of knowledge for appropriate preparation of products for the market in order to reduce wastage to a minimum. This is the situation with root crops and plantain in particular.

For the crops which are produced commercially at the present time, the volume available for food processing cannot be quantified easily due to lack of reliable [1] estimates of acreages and yields, and the inadequacy of knowledge on the range of available varieties of the majority of the crops of interest except for grapefruit and oranges. Table I sets out the existing and potential production of these two crops with an indication of the quantum of fruit that may become available to the processing industry based on knowledge of the performance of the overseas fresh fruit market.

The conclusion therefore is that whereas the quantum of available supplies of grapefruit and oranges which can be utilized for processing at the present time and in the future are known, the quantum of available supplies of the other farm products which can be processed such as tropical fruits, root crops and vegetables are not known but they are being produced and there is room for expansion of production within the cultivable land resources of Dominica.

Quite apart however from the quantum of existing and potential supplies which are available for utilization by a food processing industry, limitations are imposed by the varietal characteristics of the farm products in terms of suitability for processing and the quality of the product taste for the consumer.

It is well known that the European, British and North American markets prefer fruit products with a reasonably high acid flavour, whereas the Caribbean market prefers fruit products with high sugar flavour. Since the majority of these tropical fruits are already being produced in the Commonwealth Caribbean territories with comparatively large domestic markets, which give scope for expanded scale of operation and other derived benefits, then it appears that the market opportunities for processed food products from Dominica are restricted largely to the tastes and preferences of European, British and North American consumers. Tropical fruits as processed goods must also compete with temperate fruits. The advantage of tropical fruit products therefore will lie in areas where there are low degrees of substitutability between these two types of goods.

For example, canned mango and canned apricot are good substitutes. Canned mango, apart from the processing problem of an excessively high fibre content, is therefore subject to vigorous competition and would not stand a fair chance of survival in these subtropical and temperate markets. Mango is therefore a potential processed commodity for the Caribbean market and the cosmopolitan type metropolitan markets of London, Montreal and New York.

Whilst it is possible to generate supplies of tropical fruits, root crops and vegetables for a food processing industry because of existing supplies and available land

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1 The author is now undertaking such a survey and results will be available by January 1970

resources for expansion of supplies, the poor quality of the texture of the varieties, the undesirable tastes of the processed goods for the European, British and North American markets, and the low income elasticity of root crops limit the range of farm products largely to tropical fruits and vegetables. These are grapefruit, oranges, guava, tamarind, passion fruit, West Indian cherry and common vegetables such as cucumber. It is important to note at this point that should root crops be presented in 'delicacy' or 'novel' styles, then market demand for this type of processed food product may develop an export trade.

In the light of these facts therefore, it must be concluded that if the production of grapefruit and oranges expanding, as shown on Table I and that the quantum available for processing is dependent to a large extent on field surpluses accumulated as a result of the level of performance of the overseas fresh fruit market, then direction must be given towards the expansion of stable supplies of acid flavour, processing-type tropical fruits such as local guavas, tamarind, passion fruit, papaya, West Indian cherry, lime based beverages such as lemonade, and vegetables such as cucumber for the export markets principally, and sweet flavour processing type tropical fruits such as soursop, certain mango varieties, sugar apple, custard apple, etc., for the home, Caribbean and cosmopolitan type metropolitan market. These could also be used as flavours for local beverages consumed at home and in the region.

There is strong indication that the demand for these products on the metropolitan markets may be greater than the demand on the home and Caribbean markets. This is as a consequence of the smallness of the size of the home markets and the availability of these products in fresh and processed forms in the larger Commonwealth territories of Trinidad and Tobago, the Windward Islands, and Jamaica. There is scope however for the exploration of markets for these products in the non-Commonwealth Caribbean territories such as Martinique and Guadeloupe.

By and large therefore, such an investment project, with levels of demand and supply relatively unknown, would not attract private capital. There is need for Government intervention since this is essentially a development project which must be analysed on the merits of social cost/benefit criterion. The first phase of the production of the food processing industry is to enter these markets, to estimate the demand for the various types of farm processed goods and to sell these products. This will in turn generate the expansion of total farm output of those essential farm products which are in small supply. This would take place principally through the cultivation of existing idle land resources and farmland in relatively low market status crops. For this purpose, adjustments in production patterns will be required but this must be induced by public intervention.

On this basis therefore, the project should be financed through budgetary allocations in the development stage. At the point of change into a profitable venture, the Industry should then be made to function as a commercial enterprise. The first step in this direction should be to offer shares to farmers who supply the Industry with raw material to be consolidated with shares allocated as an incentive to encourage the sale of farm products to the Industry during the initial development stage. An inducement to farmers to supply farm products at the development stage is therefore suggested. This may be introduced either as a price support programme, or through an allocation of a unit of shares to each fixed value of farm produce delivered and accepted for processing during the establishment phase.

At its present stage of development, Dominica does not have the level of technical skills to operate a food processing plant efficiently. It is important therefore for the public sector, from the outset – in the planning stage, to secure the services of a qualified food technologist whilst a local counterpart receives such training at the professional level. In the meantime also, a local trainee should understudy the techniques of operation in the plant during the development stage.

Having established that the establishment of a food processing industry is an essential adjunct for the development of the agricultural sector of Dominica, and that demand for these farm processed goods cannot be reliably estimated in the absence of the goods on the market, with the knowledge that the volume of supplies is small, then the type of Industry that needs to be set up in Dominica is one that operates a multiple processing small scale plant which is flexible for future adjustments in scale of operation and techniques of processing, and which is allocated a stable supply of citrus fruits and the dominant raw materials for the time being.

Besides providing the capital and technical skills for the establishment of this Industry and to guide its operation through the development phase, in order to secure a bright future for the Industry assuming good market response for such products through expanding trade relations and trade advertisements, the public sector must give all the necessary incentives to agriculture through specified programmes. These are to achieve the objective of increasing total agricultural output and productivity per unit of resource employed.

The agriculture of Dominica, unlike that of the industrial territories of the Caribbean Commonwealth, has not had its fair share of public investment, despite its strategic importance for growth and development. The budgetary allocations from local revenue to the agricultural sector including farm, market, agricultural business and agri-services, for the period 1965–69 as a percentage of the total budget are as follows:–

1965	1966	1967	1968	1969
5%	5.2%	4.5%	4.4%	4.2%

It is imperative therefore that in order to influence the rational allocation of resources to agriculture, and to promote adjustments within the agricultural production system, the public sector must embark on imaginative development programmes. Consideration should therefore be actively given to positive programmes such as tax credits for investment in agriculture, agricultural

investment allowance for specific performance, supervised agricultural credit, agricultural and food processing research and a qualified and broad agricultural extension service.

The express purpose of these programmes is to promote agricultural growth in specific directions in order to supply a developing food processing industry with the basic requirements of farm products.

Table I

Existing and potential citrus production for period 1969 – 1975 indicating availability of supplies for processing.

YEAR	*Total production of Marsh seedless grapefruit*	*Estimated supplies available for processing*	*Total production of orange*	*Estimated supplies available for processing*
1969	263,550 field crates	85,000 field crates	247,800 field crates	74,340 field crates
1970	288,400 ”	115,400 ”	252,700 ”	75,810 ”
1971	316,050 ”	173,800 ”	254,800 ”	76,440 ”
1972	372,050 ”	223,280 ”	257,252 ”	77,175 ”
1973	413,350 ”	289,345 ”	259,350 ”	77,805 ”
1974	505,750 ”	366,930 ”	261,060 ”	78,318 ”
1975	601,650 ”	481,320 ”	288,750 ”	86,625 ”

Source:–*Economic Data on the Citrus Industry of Dominica,* Dr. J. Bernard Yankey – March 1969 – Agricultural Economics Bulletin, No.2. 1969–Division of Agriculture, Dominica

Citrus research in some Caribbean Territories

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Summary

The Citrus Research unit for the University of the West Indies has been in existence for nearly eight years. Some facts concerning the financing of the unit are presented. Funds are provided by the Citrus Growers Associations in British Honduras, Jamaica, Dominica and Trinidad and Tobago. The major portion of the research programme concerns problems of oranges and grapefruit in the contributing territories with some attention also being paid to limes in Dominica. The work of the unit is reviewed under four headings – Citrus Nutrition, Plant Improvement Programmes, Diseases and Pests. The importance of, and benefits from the addition of limestone to the soil in the major citrus growing areas of British Honduras and Trinidad have been clearly demonstrated. The use of leaf analysis in nutritional studies and the effects of rootstocks on nutrition are described. Two diseases, Areolate Leaf Spot and Premature Fruit Drop, which appear to be confined to Caribbean territories, are described. Mexican fruit fly in British Honduras, citrus weevils, especially in Jamaica, and leaf-cutting, fungus growing ants of the *Atta* and *Acromyrmex* species in British Honduras and Trinidad are discussed as three of the major insect pests of citrus in the territories served by the unit.

The Citrus Research Unit of the University of the West Indies was established in 1961, its research programme being based on the 1958 Wallace Report. The necessary financial support has been supplied by the Citrus Growers Associations of British Honduras, Dominica, Jamaica and Trinidad and Tobago through the British Caribbean Citrus Association. A capital grant from the British Government has enabled laboratories and housing to be built, and vehicles and special equipment purchased. By 1965, the Unit consisted of six graduates and had three field stations, one in each of the three larger territories served. A review of the earlier work of the Unit and a brief description of the contributing industries has already been given (Maliphant 1966). The major portion of the work has been directed towards agronomic problems of oranges and grapefruit with some attention being paid to the lime industry in Dominica.

It is the purpose of the present review to indicate some of the problems encountered by the Unit, agriculturally and otherwise, and progress made in the past four years.

The Citrus and Lime Industries of the British Caribbean

The finance needed to operate the research unit is derived from a cess imposed on all citrus presented in the territories concerned for export, either as whole fruit or after processing and from reserves accumulated by the industries. The expenditure by the Unit rose from £37,277 in 1964/65 to £46,721 in 1967/68 with an expenditure during 1968/69 of £40,560, representing a total investment by the citrus growers of approximately £210,000. During the same period the crops (tons of fruit) on which the research cess was levied were as shown in Table 1.

Assuming an average value of £40 per ton, it is apparent that the industry invests just under 1% of the value of its product in research. Processing and marketing costs absorb about 80% of the value and the balance represents profits to growers and producers. However, as the research cess is charged on the grower, the growers' investment ranges from about 1% in Dominica to 4% in British Honduras and is dependent on the price paid

Table 1

Year	British Honduras	Dominica	Jamaica	Trinidad	Totals
1963/4	40,300	800	52,100	30,400	123,600
1964/5	39,200	1,300	55,500	46,300	142,300
1965/6	42,800	1,400	56,300	40,700	141,200
1966/7	33,400	1,300	40,700	35,300	110,700
1967/8	34,600	1,900	48,000	25,400	109,900
Totals	190,300	6,700	252,600	178,100	627,700

to the growers by the processors. In fact, the research cess levied was insufficient to meet the costs of the Unit and withdrawals have been made from reserves and assistance obtained from outside the industry.

With the exception of a small amount of work in Dominica, lime research is not a normal part of the research programme. However, there is increased interest in lime cultivation not only in the four territories served by the Unit, but in other Eastern Caribbean territories. The major lime-producing territories in the British Caribbean are Jamaica, Dominica and Trinidad. The comparative value of exports of these territories and Mexico and Ghana are shown in Table 2 (Allen, private communications).

Table 2

Value of Citrus Product Exports (£)

	Oil	Juice	Total
Mexico (1965)	1,400,000	140,000	1,540,000
Ghana (1965)	57,000 (est.)	691,000	748,000
Jamaica (1965)	151,000	196,000	347,000
Dominica (1965)	42,800	178,800	221,600
Trinidad and Tobago (1965)	20,000	16,400	36,400

Precise data on the areas devoted to citrus cultivation in the four major territories is not available, but, Table 3 shows the approximate areas involved.

Citrus Nutrition

The programme of research in citrus nutrition involves studies of effects of fertilizer and other soil amendments on yields and fruit quality and also aspects of leaf and soil analysis both in direct relationship to yields and quality and with reference to minor trace elements (Van Wheroin, 1968).

In large areas of the major citrus-growing regions of British Honduras and Trinidad, yield increases of about 40% have been obtained merely by addition of ground limestone. Besides the gross effects on yield limestone applications have adversely affected N, K and Mg levels in citrus leaves (Weir, 1969).

In West Indian citrus, the predominant nutrient need is for nitrogen. It has been found that the N levels in

Table 3

Estimated Areas under Citrus (ha.)

Country	Oranges	Grapefruit	Limes	Total
British Honduras	2,500	840	40	3,300
Dominica	400	560	920	1,900
Jamaica	17,200	5,200	1,400	23,800
Trinidad and Tobago	2,800	4,000	20	7,000
Totals	22,900	10,600	2,380	36,000

citrus leaves suggested as optimal in subtropical areas are close to these required in the wet tropical areas of the Caribbean. Much of the Caribbean citrus has less than optimal N contents and emphasis must be given to nitrogenous fertilizers. However, the form of fertilizer used is controlled more by price and availability than by one form being better for the citrus than another. The use of a nitrification inhibitor has been shown to greatly reduce leaching losses of nitrogen so leading to a more efficient utilization of fertilizer applied. It is not known what effect NH_4^+ nitrogen nutrition of citrus would have under tropical conditions on fruit yields and quality. Results from subtropical areas suggest that NH_4^+ nitrogen nutrition gives better quality fruit than NO_3^- nitrogen nutrition.

Deficiency of magnesium is widespread in citrus areas of the Caribbean and is accentuated by potash applications and the presence of limestone in the soil. Potash fertilizer has a very marked effect on leaf magnesium levels and on fruit quality – reducing fruit size, soluble solids and juice content and increasing acidity. However, the application of magnesium fertilizer has only a small effect on uptake of potash and virtually no effect on fruit quality. Uptake of zinc and manganese is increased by applications of magnesium.

The use of leaf analysis of citrus in the wet tropics is becoming firmly established as a guide in fertilizer recommendations. It is not yet possible to define optimum levels of nutrients in citrus leaves. However adequate leaf magnesium, zinc and manganese levels in the Caribbean area are probably higher than for sub-tropical areas.

Analysis of leaves from the same variety of citrus on different rootstocks has shown very marked variations. Thus leaves of Valencia orange, Marsh grapefruit and Ortanique orange were relatively rich in potash and poor in calcium and magnesium when on Rangpur lime stock and the reverse when on Cleopatra mandarin stock. Leaf contents of zinc and manganese tended to be low when the rootstock was Troyer citrange or Trifoliate orange. These characteristics are of importance in the selection of a rootstock. Thus considerations of soil nutrient supply and the ability of the rootstock to extract the nutrients may become as important as the fruit quality characteristics associated with that rootstock.

Plant Improvement

The quality of plants issued to growers in the four territories served by the Citrus Research Unit varies considerably. In British Honduras, plant production is in the hands of unregistered nurserymen and Government Agricultural Stations. Only in recent years has the control of importation of budwood been tightened. There is no control over the nurserymen. However, the value of improved nucellar budwood is being demonstrated in field trials. In Jamaica all plant production is controlled by Government but new improved budwood is only slowly reaching the growers. The very small, but important, citrus industry in Dominica is in a similar state to that of British Honduras. In contrast, legal importation of budwood into Trinidad was virtually nil for the 20 years 1945–1965. Hence the majority of citrus orchards are based on budwood imported from the USA in days when the existence of citrus viruses was only just being appreciated. Improved budwood was imported by Citrus Research in 1965 and this is now being received by growers although there is still little formal control of the budwood sources of other nurserymen. Approximately ten years ago, a nucellar programme was initiated by the Government research personnel in Trinidad. This programme was taken over by Citrus Research and is now reaching its final proving stages. It is hoped that by 1975 tested nucellar budwood developed entirely in Trinidad will be available to growers initially through the Citrus Research nursery and subsequently through Government and other nurseries.

Disease Problems

Two disease conditions have, in recent years, appeared in the Caribbean which, so far as is known, are absent from the United States mainland. These are Areolate leaf spot and Premature fruit drop.

Areolate leaf spot (*Corticium areolatum* Stahel) was first noted in Trinidad in 1967. The following year, probably because of favourable climatic conditions, this disease became a serious threat to the citrus industry. Government assistance was granted and a control programme initiated under the control of the Citrus Growers Association. This programme has illustrated the difficulty of spraying under wet tropical conditions with heavy clay soils. In most areas tractor-drawn equipment was unusable and the programme relies on teams of motorised knapsack sprayers. This is a slow programme and a complete rapid coverage of all citrus was not possible. However, growers have been encouraged to establish their own spray programme and those who have, have been successful in reducing the incidence of the disease in their groves. The chief fungicidal component of the spray programme is copper and the formulation marketed as KOCIDE 101 has proved to be of outstanding value.

Premature fruit drop is a condition prevalent in parts of British Honduras but little known elsewhere. The very young fruit separate from the pedicel and fall, leaving the pedicel attached to the tree where it remains for many months fresh and green. When the citrus tree employs the normal fruit drop mechanism to control the crop, the pedicel is lost with the young fruit. It has now been established that the condition is caused by a fungus which is controlled in part by properly timed fungicidal sprays. A recently developed systemic fungicide, Benlate, has shown to be effective. This is also very effective at low concentrations against scab disease and greasy spot.

Pests

The pests of citrus which are particularly troublesome in the territories served are the Mexican Fruit Fly, Citrus Weevils and leaf-cutting, fungus-growing ants.

The Mexican Fruit Fly (*Anastrepha ludens Lw)* has been present in British Honduras for many years, but it was not until after hurricane Hattie (October 1961) that it became a serious cause of loss of mature fruit. Early experiments showed the value of a foliage spray of malathion and hydrolysed protein bait to control the adult flies and a soil treatment of dieldrin to control the larval stage. The demonstration of the control led to the principal growers using aerial equipment.

There are still unanswered problems in the Mexfly work. A trapping programme has shown that, despite the ability of the Mexfly to fly considerable distances, the same areas appeared as centres of infestation in successive years. This effect persisted despite the apparent changes in habits of the flies. In early years, mainly grapefruit was attacked and only minor infestation was found on oranges. In 1966 and 1967, more fruit flies were trapped in orange groves than in adjacent grapefruit grooves; but by late 1968 and 1969 this trend had been reversed.

Parasites of Mexfly are known in Mexico but at one time it was felt that these had not been introduced into British Honduras when the Mexfly spread eastwards. Attempts are now being made to identify the few parasites which have appeared in British Honduras and to estimate their effectiveness in preparation for an importation of parasites.

The Mediterranean Fruit Fly (*Ceratitis capitata* Wied), is, at present, not apparently spreading northwards through Honduras and few reports have been received of its progress towards Trinidad from western Venezuela. Other fruit flies are of minor importance to citrus in the West Indies.

Citrus weevils of several species are problems as leaf-eaters and root-eaters of citrus. In Jamaica, several species of parasites have been identified, but control at present is largely dependent on chemical control. The citrus weevils of Dominica and British Honduras are different species from those in Jamaica and appear to be under natural control.

Finally *Atta* and *Acromyrmex* ants devastate citrus groves, particularly new plantings, by their leaf-cutting activities. It was once thought that these species were restricted to the American mainland and Trinidad and Tobago. It is now known that *Acromyrmex* spp. exist in Carriacou in the Grenadines and Guadeloupe and an *Atta* sp. is present in Cuba. This distribution poses intriguing questions of dissemination such as the reasons for the absence of either genera from Grenada,Antigua, Dominica, Hispaniola, Jamaica and Florida.

Atta ants tend to produce large, more obvious nests than *Acromyrmex* sp. However, *Acromyrmex* sp. queens are smaller and produced in larger numbers per nest than *Atta* queens and therefore more new nests are produced by *Acromyrmex* and, aided by their less conspicuous nature, this species is a more serious pest.

Control measures have involved finding the offending nest, excavating it and/or treating it with insecticidal material such as boiling water, carbon disulphide, aldrin, dieldrin, etc. In 1964, poison baits were introduced into the West Indies. A chlorinated hydrocarbon insecticide, is incorporated in a base made up of material attractive to the ants (largely citrus pulp) and the product granulated. The ants then transport the bait to the nest where the insecticide is able to kill many of the ants. There are several products on the market usable as poison baits —Hormifin, Camani, Parasol, Mirex, etc. However, they all suffer from the same drawback of being gradually rendered unattractive to the ants by the presence of water either as dew or rain. Attempts to protect the bait by a water-proofing process have met with initial success and it is hoped to carry out relatively large scale trials in the near future.

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Improving some tropical fruit plants

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Summary

Four years ago a programme to improve the less widely cultivated and commercialized fruit plants was initiated in Trinidad and Tobago. The programme can be divided into three phases. (i) Collection of the best local selections and the introduction of improved types from other countries, (ii) the development of propagation techniques where these do not already exist and (iii) the establishment of orchards for scion material, observation under similar environmental conditions and the development of commercial orchard techniques.

Progress has been extremely rapid. Many improved types have been collected, propagated vegetatively and orchards are now being established.

A brief description of the methods employed and the results achieved are given.

Introduction

Changing patterns in developing countries in the social, political and economic spheres all exert influence on the relative importance of the various crops: in the past research facilities have been devoted almost exclusively to the major export crops.

Price fluctuations of these export crops are leading to a deliberate policy of seeking alternative crops, particularly those which can be consumed locally or manufactured into acceptable products for both home consumption and export markets. Such crops could have the twofold advantage of reducing food imports and of earning foreign exchange. Export markets are developing for new tropical crop products and improved transport and refrigeration facilities have considerably widened the range of tropical crops that can be exploited. Within Trinidad and Tobago rapid population growth and increasing urbanization are creating markets for products which did not previously exist. Better education and improving standards of living also serve to increase this market. All these factors influence the outlook for an increased commercialization of a wider range of tropical crops and particularly the lesser utilized tropical fruit crops.

This optimistic outlook concerning the potential of the lesser known tropical fruits is hardly justified on the basis of our knowledge and experience of these crops. Indeed until recently nothing has been done to improve this large range of fruits. All present cropping comes from seedling trees in home gardens or naturally propagated growth in the field. Trees are invariably seedlings and even though some selection of seeds from superior trees has been practised, the plant population is very variable, ranging from good or even excellent to barely edible.

In 1965 a programme was initiated at the Central Experimental Station of the Ministry of Agriculture to improve a wide range of the lesser commercialized tropical fruit crops. So far 17 types of fruit have been receiving some attention. The station staff consists of one qualified Horticulturist, one Assistant and a skilled Nurseryman. It was indicated at the start that results should be obtained quickly and all work must be of immediate practical application.

The programme of work can be summarized as follows:

(1) Location of trees of the better types of each fruit in the country and introduction from abroad wherever possible of improved selections.

(2) Development or adaptation of vegetative propagation techniques for rapid multiplication.

(3) Establishment of small orchards of selections for critical appraisal and determination of orchard practices for commercial production.

Collection of superior selections

No exhaustive investigation was undertaken to study the entire range of each type of fruit, as facilities and time were limited. Two broad distinctions were made at the start, – (1) fruit for the fresh fruit market and (2) fruit for processing. Size and external appearances were not considered important for fruit intended for processing.

Characters for Selection

Early in the programme certain characters were decided upon for guidance in selection. These are summarized as follows:

i. *Palatability*

Pulp or juice with an attractive flavour, free from unpleasant background flavours or astringency, free from strings or stones or with the minimum of these.

ii. *Skin*

Brightly coloured, smooth and free from scars.

iii. *Size*

Fruit about 100g preferable. Where the size range is higher, the smaller fruit to be selected: where lower, the larger fruit.

iv. *Shape*

Round fruit in preference to other shapes.

v. *Seeds*

Fruit with few or small seeds preferably free or easily separable from the flesh.

vi. *Season of Cropping*

Differences in cropping season to be sought in order to lengthen the harvest period.

vii. *Fruitfulness*

Heavy cropping most desirable.

viii. *Pest and Diseases*

Freedom from pests and diseases.

Where variations in these characters existed, selection was made for them. It was soon obvious that many of these characters were modified by environment and so objective measurements were discontinued and selections were made simply on the first two characters, i.e. attractiveness of flavour and appearance: frequently, it was simply a question of whether the fruits were edible at all.

To assist location of the better types of fruit, appeals were made through the news media and the Extension Services, but unexpectedly response was very poor. Some planters contacted individually were of the greatest help, and school children were also helpful. Visits to fruit and vegetable markets and roadside stalls were useful, but although many good types were seen, vendors were often reluctant to divulge their sources of supply.

Owners of selected trees were given vegetatively propagated plants and the selection was named at their choice. Usually owners allowed only very restricted removal of propagating material and this was often stopped when they had received a few plants. Money payment was seldom effective in allowing unlimited access to selected trees. As a result of only limited access and the restricted quantity of propagating material available, rapid multiplication can only be considered when sufficient stock has been built up.

Development of Propagation Techniques

The development of vegetative propagation techniques for many of these fruit proved simple, because the necessary skills were available and because of the existence of extensive, efficiently run propagating facilities for rooting cacao. Semi-hard, terminal cuttings produced on pollarded trees gave good rooting results with guavas (*Psidium guajava L.*), West Indian cherries, (*Malpighia glabra L.*), dunks (*Zizyphus mauritiana* Lam.), Governor's plum (*Flacourtia indica* Merr.), and pommerac (*Eugenia malacensis* L.). The rooting medium was coconut fibredust. An IBA/NAA mixture at half the strength used for cacao, encouraged rooting. For some cuttings such as guavas, a fungicide dip was necessary to reduce damping off. For some plants, where insufficient material was available for propagating by cuttings or where poor rooting was obtained, side grafting was very successful. Plants such as mammey apple (*Mammea americana* L.), sapodilla (*Achras zapota* L.), tamarind (*Tamarindus indica* L.), pomme cythere (*Spondias cytherea* Sonn.), mangoes (*Magnifera indica* L.) and avocados (*Persea americana* Mill.), are readily propagated by this method, using young material grown in plastic bags and grafted when just over pencil thickness.

Orchard Establishment

Once suitable selections had been made and propagation techniques developed, small orchards of about a hectare were planted. This stage has been reached with nine of

the seventeen fruit crops on which work is being done. These orchards are intended to provide a more critical evaluation of the various selections and to provide a source of scion material for further multiplication. They will also provide information on those crops under orchard conditions, indicate problems for future research, provide demonstrations to interested farmers and give some indication of costs and returns. The fruit from these orchards can also be used to determine market acceptance and develop acceptable processed products.

Utilization

If this work is to have any practical value, it is necessary to determine as early as possible whether these fruit can be marketed either fresh, processed, or both. This question is of major interest to potential growers and the answer would help to determine priorities for future work. Whenever fruit in quantity is available from either parent tree or orchards, it is sent to local markets to determine the price it will fetch and rate of sale. Occassionally, small quantities have been air-freighted to foreign markets. Responses to such trial shipments have been favourable.

Although there are several food processing factories in the country, they do not yet have the facilities to develop high quality processed products from these fruit. Because of this and the necessity for determining the important factors in selecting fruit for processing, some attention was devoted to making, in the laboratory, products like jellies, jams, nectars and wines. These products have helped considerably to build up interest among farmers and processors alike.
To illustrate this approach, it is appropriate to describe the work on two selected crops, guava and papaya.

Guavas (*Psidium guajava* L.)

Selection

In 1960, yield, soluble solids and acidity records were taken for all plants in a hedge of seedling guavas. Guava jelly was made from fruit of the five highest bearers. A tasting panel was overwhelmingly in favour of the jelly made from the fruit of one of the five trees, which had the highest acidity of all the trees examined. Unpublished work from Puerto Rico subsequently confirms that very acid guavas make the best quality processed products.

This seedling was vegetatively propagated by layering and 2,000 sq. metre plot was planted in 1961. Cropping started in 1962, and yield records from 1965 are given below:–

1965 – – – 24.100 metric tons/ha
1966 – – – 65.850 metric tons/ha
1967 – – – 64.800 metric tons/ha
1968 – – – 38.680 metric tons/ha

Fertilizers were applied to the field from 1965 onwards. After the 1967 crop, alternate trees in the plot were cut back heavily to produce material for propagation so that the yield in 1968 was from half the trees previously recorded. It was obvious quite early that the selection was capable of heavy yields.

Propagation

Guavas are propagated from soft tip cuttings under mist in other countries (Pennock and Maldonado, 1963; Le Bourdelles and Estanove,1967). No such facilities were available, but there is an abundance of cacao propagation facilities. (de Verteuil, 1956). Early attempts to utilize these facilities for guava propagation were unsuccessful because of the high incidence of leaf spot (*Glomerella cingulata* (Stonem.) Spauld and Shrenk), but this was controlled by a proprietary Copper Zineb mixture, used for dipping the cuttings before insertion.

A range of concentrations of IBA and NAA, singly and in combination were compared for hastening the rooting process: a combination was found to be most effective. A sufficiently good root system is formed in 18 days, more than 90% rooting being achieved. Over the last year, 56,000 plants have been produced.

Fruit Fly Control

In Trinidad most guava fruit are infested with larvae of the West Indian Fruit Fly (*Anastrepha suspensa* Loew): such fruit are unsuitable for processing. Here again this small orchard was very useful. The first problem was to determine the stage of fruit development at which the insect lays its eggs in the fruit. Fruitlets were enclosed in small polythene bags soon after fruit set and fruit from the same flowering were bagged at 3–day intervals subsequently. Fruits were examined when ripe for infestation. It was found that the insect was only attracted to the fruit when ripening had commenced as shown by the change of the pulp around the seed from white to pink. At this stage the fruit was still hard and green, full ripeness occurring 16–21 days later. Having determined this, various insecticides were compared. Several proved effective when applied at weekly intervals, starting when the first few ripe fruits were visible on the trees. Sevin is used in preference to the other insecticides because of its low mammalian toxicity, and results in complete control of the fruit fly.

Utilization

Uniform, high quality fruit from this orchard were used in the laboratory for preparing a range of guava products. Sufficient fruits were also available for several processors to manufacture and introduce some of these products to consumers.

A considerable amount of knowledge was gained from this orchard of guavas, on spacing, pruning, weed control, harvesting and fertilizer response. On the basis of this information more detailed experiments are being planned. Knowledge gained has been embodied in an advisory bulletin which is handed out to farmers when they purchase plants.

The guava has thus been taken from a wild plant with limited utilization to a cultivated orchard crop of high yielding clonal material producing uniform high quality fruit. Further research is planned but the priority to be given to such work depends on the acceptance of farmers of the knowledge and material now available and the consumer acceptance of the fruit products. The outlook appears favourable on both counts.

Papaya (*Carica papaya* L.)

Papayas or pawpaws have not been cultivated in Trinidad for more than 30 years, mainly because of virus diseases, which kill off the trees before fruit can be harvested. Small quantities of fruit however can always by found on the market, coming from trees in home gardens and scattered uncultivated seedlings. This suggests that some plants escape the viruses.

Very little research has been done on this crop in Trinidad and Tobago. Baker (1939) reported the occurrence of Mosaic Virus and considered it the limiting factor in papaya cultivation, but Castelli (1939) claimed that Mosaic was a result of inadequate nutrition. Thorold (1948) compared various levels of organic and inorganic manures on the crop and concluded that the mosaic was caused by a virus and was not a soil problem. He also stated that 'yields were significantly and economically increased by the manures and fertilizers used in these trials.'

In Puerto Rico, Mosaic and Bunchy Top Virus were transmitted under controlled conditions (Adsuar, 1946; Martorell and Adsuar, 1952). There is little doubt therefore as to the viral nature of these papaya diseases. Naylor (1965) reported the successful control of Bunch Top Virus in Jamaica by spraying with Sevin or Rogor for insect control.

Selection

This suggested that, in spite of current local opinion and experience, papayas could be grown successfully. An improvement programme was therefore initiated. Introduced varieties and local selections were grown to gain experience with the crop and to develop and maintain pure strains.

Seeds from selected local plants produced a variable range of progeny and even controlled pollination resulted in only a small reduction in this variability in the second generation. It was very noticeable that bisexual types were very much less variable and that anthracnose resistance appeared to be related to skin type, smooth skinned varieties being less susceptible.

Four strains have so far been selected and further work will be continued to improve these. One has a mean fruit weight of 2.9 kg and firm yellow flesh suitable for processing into slices in syrup. Another is pink fleshed and high yielding and suitable for harvesting as green fruit for the factories. Two types with small fruit, and attractive skin colour have been selected for the fresh fruit market.

Yields of female plants used as parents were recorded: The six best are given below.

Table I

Tree No.	*Yields in kgs*				
	1966	*1967*	*1968*	*1969*	*Totals*
8/66	238.2	588.5	116.2	419.8	1,362.2
1/66	144.3	131.5	332.0	–	607.8
3/66	117.9	159.3	87.6	–	364.8
2/66	85.7	118.0	154.3	–	358.0
6/66	139.8	168.0	–	–	307.5
13/66	132.5	24.9	101.6	–	258.0

These yields would have been substantially higher if the trees had not been sprayed in error with Diuron. Tree 8/66 escaped the worst effects because it was taller than the others. The high yield of this same tree in 1969 was due to cropping on side branches. All the other plants had toppled over during high winds in 1968 since the soil on which they were grown is continuously waterlogged during the rainy season and roots do not penetrate below 20–30 cm.

Virus Incidence

Over the last 3 years 2.95 ha of papaya have been grown, on two most difficult soil types and not a single tree has

been observed with obvious virus symptoms. All losses have been from root rot or toppling; problems which can be expected on heavy soils with impeded drainage.

Fruit Fly Control

Early in 1960, infestation of the fruit with the fruit fly larvae (*Toxotrypana curvicauda* Gest.) was noticed, in spite of fortnightly sprays with Sevin. Examination revealed that all infestation had occurred at the stylar end of the fruit. Deliberate direction of the spray to this part of the fruit during the spraying operation subsequently gave complete control of this pest.

Utilization

Over the three years 1966–1968, more than fifty metric tons of fruit were marketed. The small-fruited selections have proved very popular: one supermarket sold more of these fruit each week than had been sold of the usually available types in the five preceding years. The larger proportion of the fruit was sold to a factory which marketed a papaya nectar that was very well received. Green fruit was used by the same factory as a filler in various food products.

Conclusion

Progress on guavas is more advanced since work has started four years before that on other crops: papaya being quick growing has given information more rapidly. These two crops serve to illustrate the programme of improvement. Seven fruit crops have reached the orchard establishment phase and within another five years sufficient information should be available to assess the potential of these crops and material should also be available to multiply them for distribution to growers.

Many criticisms can be directed against this approach to an improvement programme but I feel that it is the most appropriate at this stage and with the resources available. In defence I may say that practical results are being achieved rapidly. In addition three most important requirements for critical research are being provided namely: uniform planting material, knowledge of how to grow these crops in the orchard and identification of the problems that need to be examined further.

There is little point, of course, devoting scarce resources to more critical work on any of these crops until they are under commercial cultivation. Future work is therefore very much dependent upon commercial exploitation of material and information, as these become available.

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The Puerto Rican chironja – a new type of citrus

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Summary

The chironja, a new type of citrus, was found by the author in 1956, in the central mountains of Puerto Rico. This new fruit appears to combine desirable characteristics of the orange and grapefruit. It is generally similar to a grapefruit in size, although slightly more elongated. At maturity the outer rind is bright yellow and glossy and the pulp is orange colour. The flavour is best described as a combination of sweet orange and grapefruit, without the acidity of the former or the bitterness of the latter. The chironja is a versatile fruit of various table uses having a vast commercial potential. It may be eaten as a grapefruit, cut in half, or peeled and eaten as a tangerine, or it may be utilized for juice, one average chironja yielding the equivalent of 2 medium sized Valencia oranges. The average chironja weighs 500 grams, the number of seeds per fruit varying from 7 to 15. It is nucellar. Field experiments have been conducted over a period of ten years with seedling and grafted trees. Some ever-bearing trees have been observed. Chironjas were found easy to process in canning experiments reported in 1965. No difficulties were experienced in removing the peel or in separating the sections. Some research has been conducted on adaptation to various environments, grafting and behaviour of progenies from selected material. Research now in progress proposes to elucidate the true nature of the chironja through botanical and cytogenetical studies comparing characteristics of this fruit with grapefruit, *Citrus paradisi* Macf. and orange, *C. sinensis* (L.) Osbeck.

*Paper read *in absentia* by J. Marriott, Tropical Products Institute.

The Puerto Rican Chironja is a delicious new addition to the citrus family. This new fruit which was discovered in 1956 (Moscoso, 1958) growing wild in the mountains near Utuado, Puerto Rico, appears to combine very desirable characteristics of orange, *Citrus sinensis* (L.) Osbeck, and grapefruit, *Citrus paradisi* Macf. In fact, these characteristics are so notable that the name 'Chironja' selected for the fruit is a combination of the Puerto Rican names for orange and grapefruit, i.e., 'China' and 'Toronja', respectively.

In February, 1956 while in charge of the Citrus Marketing Project at the Agricultural Experiment Station of the University of Puerto Rico (Moscoso, 1957) the writer made many field trips to the coffee zone of the island to look for new and promising varieties of oranges. On one of these field trips the tree to which the name 'Puerto Rican Chironja' was given, was first observed.

While inspecting an orchard in the vicinity of Utuado, Puerto Rico, high up in the mountains, the writer was impressed with the appearance of one particular tree. It was unusually large and laden with bright, glossy, yellow fruit, quite different in appearance from the orange and grapefruit trees surrounding it. The taste of the fruit was a fascinating combination of both orange and grapefruit flavours.

Upon questioning the farmer on whose land this tree was growing it was learned that this particular tree and a number of others like it growing on neighbouring farms had all been propagated from seed. It was stated that the few farmers who possessed these unusual trees had rarely marketed the fruit, but rather, in view of the superior flavour, size and keeping qualities, had preferred to keep the fruit for the use of their own immediate families.

Seed and vegetative propagating material for making grafts were collected, and early in 1957 propagation of this new citrus for experimental purposes was begun.

The fruit of the chironja may be compared with the average grapefruit in size. At maturity the peel becomes a bright, glossy yellow while the inner flesh is orange in colour. The flavour of the juice and pulp is a combination of orange and grapefruit, but with neither the acidity of the orange nor the bitterness often characteristic of the grapefruit, (Moscoso, 1958).

When the chironja is grown in partial shade the trees tend to be large and columnar. However, chironja trees grown in full sunlight have the typical rounded form of citrus. Branches are irregular and on the young twigs and shoots of some trees there are thorns similar to those produced by young seedling grapefruit trees. In general the foliage of the chironja tree is quite dense, the leaves being a deep, bright green. Branches are rounded and generally smooth, although on some trees a slight pubescence has been observed on the under surface of the union of the trunk and smaller branches. The average height of the chironja tree is approximately 8.3 m.

The leaves are quite similar in appearance to those of the grapefruit, and are usually large with prominent veins. Leaf texture is thick and strong. They are irregularly undulated, shiny, even waxy in appearance. When bruised, an aroma similar to that of grapefruit leaves is noticeable. On a mature tree the average length of leaves is 140.6 mm with an average width of 70 mm.

The fruits of the chironja are borne singly or in bunches at the ends of branches. Fruits vary in shape from globose to pyriform being somewhat obloid. The fruit is usually larger than the grapefruit, although occasionally smaller fruits about the size of a large orange are produced. The base or stem is slightly to prominently collared and depressed. The collar is often longitudinally furrowed or ridged. The apex has a very small stylar scar surrounded by a prominent grey to tan area approximately one-half inch in diameter. This peculiar circular area is a characteristic the writer has observed in all chironjas which he has examined.

The diameter of the fruit varies from 92 to 110 mm, with an average diameter of 101 mm. Height ranges from 90 to 134 mm, with an average height of 111 mm. (Moscoso, 1964).

The bright yellow outer rind of the fruit is similar to the grapefruit in aroma. Thickness of the rind varies from 5 to 8 mm, with an average of 6.8 mm, the rind representing 24% of the total weight of the fruit. Texture varies from smooth to slightly rough. Although the rind is thick, it is as easy to peel as a tangerine. Fruit sections also separate very easily.

The edible portion of the chironja contains nine to thirteen segments, with an average of eleven. The septa or thin covering of each segment is very tender and may be eaten without distaste. The clear, sweet juice of the chironja is light orange in colour. The size of segments varies from 39 to 44 mm in width, with an average of 40.2 mm and length varies from 79 to 90 mm, with an average of 84.5 mm.

The fruits are easy to process and no difficulties were experienced in removing the peel or in separating sections. Shelf-life studies showed that the canned product kept very well in storage at 85°F. for over one year (Benero and Carlo Velez, 1965).

The chironja is nucellar. Its seeds are light ivory coloured with a slight pinkish tint. Fairly large, they compare in size and shape with the seeds of the grapefruit and the orange. The number of seeds in each fruit varies between seven and fifteen, with an average number of eleven seeds. However, a few trees have fruits containing only two seeds. (Moscoso, 1964).

In field trials conducted with 500 seedling chironja trees none reverted back to either orange or grapefruit, but rather maintained true-to-type characteristics of this new citrus. Undoubtedly this is a form of apomixis. It is possible that the chironja may be the result of a natural cross of orange and grapefruit. If this is true it is evident that such a cross has become sufficiently stabilized to permit the development of this new type of citrus capable of reproducing its characteristics by means of propagation by seed, (Moscoso, 1964).

The flowers of the chironja tree are white. They develop singly or in bunches at the ends of the branches. The flower contains 5 sepals and 5 petals and has from 10 to 25 stamens with fairly large anthers. Flowers are produced on different trees during all seasons of the year in Puerto Rico, generally in greater abundance during late spring and early summer. This means that it is possible to harvest fruits at any given time of year on selected trees. A few ever-bearing chironja trees occur.

During more than ten years of field research more than twelve selections of chironja have been made, three of which are considered to be outstanding: M-1, with good appearance, shape and productivity; M-2, which is a late yielding line; and M-3, which has good appearance and is a very heavy yielder.

A current project places emphasis on the botanical differences between the chironja, on the one hand, and orange and grapefruit on the other, including cytogenetical aspects and chemical analyses. Results of these studies will be published upon completion of the project.

Cytogenetic studies indicated that the chironja, as most other varieties of citrus, contains nine pairs of chromosomes. Its pollen is very fertile but its chromosomatic ratio does not confirm whether or not the chironja is a cross between an orange and a grapefruit. The possibility is not, however, eliminated (Virkki, 1964).

Chemical analyses showed that the chironja is much less acid and much richer in sugars than the other two fruits. It is noteworthy that the chironja and the orange showed the same ascorbic acid content, 39 mg of ascorbic acid per 100 ml of juice for both fruits.

The high sugar and low acid of the chironja was confirmed by work at the Biochemical Laboratory of the National Institute of Agronomical Research, Madrid, Spain. According to the results of both analyses, one litre of chironja juice yields an average of 95.6g of sugars and 5.9 g of acidity. It seems apparent then that the chironja is a superior fruit to other citrus varieties now under cultivation.

It is possible that the characteristics and good qualities of this new type of citrus can aid greatly in improving and strengthening citrus marketing in Puerto Rico and other citrus producing areas. The chironja has the important advantage of being utilized in three different ways as a table fruit: (1) cut in half and eaten with a spoon in the accustomed manner of eating grapefruit; (2) peeled and the sections eaten like a tangerine; and (3) squeezed for juice like an orange. This versatility

makes the chironja outstanding among citrus fruits. (Moscoso, 1958).

In 1957 and again 1964 preliminary market trials with the chironja were sponsored by the Agricultural Experiment Station of the University of Puerto Rico for the purpose of determining the degree of acceptance of this new fruit by consumers at selected supermarkets in San Juan. The results of these trials, which have not yet been published, showed that the chironja was exceptionally well accepted, selling at a higher price than other citrus fruits in season. Also, the supply of chironjas sold considerably faster than other citrus fruits offered for sale at the same time.

One seven year old chironja tree can produce from 400 to 600 fruit during a period of 12 months. Also as indicated previously, both late and early-bearing varieties are known, which is another important factor for commercial plantings.

Commercial chironja orchards have been planted in Puerto Rico as well as in the continental United States and Hawaii. Interest in this new fruit continues to grow. Hundreds of letters of inquiry have been received from interested persons from all parts of the world. Small farmers, large citrus growers, nurseries, processing plants and scientific institutions are constantly requesting propagating material and more information concerning this new fruit.

It is evident that the different ways of consuming the fruit of the chironja, the commercial possibilities for utilization of its easily peeled rind, the high vitamin C content of its sweet juice, its low acid content and the easy method of propagation by seed give this new citrus fruit an incalculable potential value for those areas where climate and environmental conditions are favourable for its growth and production.

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Discussion

Dr. Sinnadurai: Dr. Yankey, you have said that the multi-million dollar tomato factory failed in spite of a promising feasibility study. Can you give some of the reasons for the failure?

Dr. Yankey: Not because of lack of demand for the product, or lack of supply on the farms. I think the major problems were:

The industry had to operate on a commercial basis from its establishments, and give farmers prices for their produce equivalent to the fresh fruit market. Farmers preferred to hold back the fruit in the expectation of higher prices. There was a lack of co-ordination of services, between production and marketing. The plant had to find its own outlets, and use its own services to get the product on the market. The high cost involved may also have been a factor.

Mr. Mulherin: Is it feasible for a small island such as Dominica to subsidize such an industry? It has been done before in many countries, but can an island with such a low income seriously undertake this sort of activity? Dominica has to compete with Jamaica and Trinidad, which both have well developed industrial centres. Perhaps it would be more realistic to operate the plant for the Caribbean area, with some sort of specialization agreed between the different islands.

Mr. White: Large sums of money go into the development of schools, roads and things of this nature and these are areas which are considered vital. Nobody has ever questioned the need for this. People must go to school: roads must be built. I am arguing that there also is some reasonableness about government subsidizing a small operation of a multiple processing type that can be economic only in the long run. We start from the position of an existing production pattern, and even in countries like Great Britain, the pattern has been to let production lead the way. Marketing has been a supplementary exercise. In underdeveloped countries also, most of the investigations have gone into production facilities, so that the goods produced were orientated with little regard to the marketing situation. So we have a vast variety of what might be called exotic products, for which there is no market. Instead of trying to expand the production of bananas in the Windward Islands let us consider crops with which the region as a whole is familiar and see whether we can find answers to the successful marketing of these crops. This requires complete reorientation in the attitudes of the Governments. We know nothing about the marketing possibilities of some crops. Bananas are accepted on the UK market, so are grapefruit. Possibly there are other products which can be accepted if they are presented in an acceptable way. Many products have been made and we cannot dispose of them. The results of the colonial pattern of development has been the production of a relatively restricted number of commodities known and accepted on overseas markets, and the almost complete disregard of the possibilities of developing other commodities for the world at large. By investigating the possibilities more widely we may be able to reconcile production with marketing.

Mr. Albert: What conditions would West Indies banana growers like to see accepted before any agreement was reached involving UK entry to the Common Market?

Mr. Spector: We would hope to become an associated overseas territory (AOT), and treated as French and Italian AOT's have been treated. We would then like to see the 20% tariff in favour of AOT's maintained. Liberalisation is one of our headaches: we would like to see quota system by convention applied to the Caribbean. That is, quota by licence. This has been discussed in one of my papers referred to here.

Dr. Godfrey-Sam-Aggrey: It appears that West Indian citrus is not bothered by *Tristeza* virus – is this correct?

Dr. Maliphant: *Tristeza* is not a problem in the Caribbean, although a few trees appear to have a mild form. There are two vectors involved. One is absent from the

Caribbean area, but is present in Guyana. At tropical temperatures and humidities the other vector becomes inactive or is attentuated.

Dr. Randhawa: I would like to know how it is proposed to maintain Mr. Bharath's papaya selections pure when propagated by seed?

Mr. Bharath: It will be very difficult to keep them true. I have observed through three generations and feel we are selecting a single strain. There are three broad types found in the country; all of which have characters which make them saleable.

Dr. Randhawa: In India we have a variety which produces only female and hermaphrodite flowers, and no males. It is a dwarf variety and bears a heavy crop of uniform fruits. Have you similar varieties in Trinidad?

Mr. Bharath: With the selection made for processing fruit, the plants are unisexual. I prefer this as their behaviour is more predictable. For green fruit a bisexual type has been more than 90% true. Small fruited types have complicated sex lives. I think the important characteristics are appearance, firmness of flesh and size. Through three generations although there has been variation, most fruit are quite acceptable.

Mr. Walker: Are aldrin and dieldrin applied as foliar sprays in citrus?

Dr. Maliphant: No, not under any conditions. These are soil treatments.

Seventh Session

Thursday 18th September
Morning

Chairman
Professor E. A. Tai
Professor of Crop Science,
The University of the West Indies

Growing and by-products of dates

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Summary

The date palm, *Phoenix dactylifera* L. is one of the oldest of cultivated trees. It requires a dry climate with high temperatures, ample sunshine and a sufficient water supply, and can tolerate high but not excessive salinity. Various cultural practices are outlined and factors affecting the production of a date grove are discussed. Dates are classified into: soft, semi-dry and dry varieties; examples are given. Yields vary between 20 to 100 kg. dates/adult tree. The most important pests and diseases are outlined.

The fruits are a very rich source of energy and other parts of the tree are manufactured into a variety of articles. The best quality dates are processed in packing houses for export, whereas the bulk of the production is processed by means which differ from one country to another. Methods of processing are discussed. Inferior quality fruit are utilized for the production of some important by-products such as date syrup and date paste. Various examples are cited to illustrate the production of a mixed and/or enriched date paste with different food ingredients such as milk, oils and protein-rich products. The tree itself is tapped for the production of a sweetish sap which is used in the preparation of an alcoholic beverage and/or of a palm sugar.

The date-palm *Phoenix dactylifera* L. is one of the oldest cultivated trees in the world. The genus *Phoenix* has about 12 species, among which *P. canariensis* Hort. is a well known ornamental palm, and *P. sylvestris* Roxb. is a sugar source in India.

The cultivation of the date-palm is more concentrated in the great desert areas extending from western-north Africa to India, although it has also become a basic commercial commodity in California (Elmer *et al* 1968a). Date-palms are also found in S. America, S. Africa and Australia as reported by Breyer (1959), Gomes (1961), Richardson (1952), and Smit and Preez (1955). A few date-groves also occur elsewhere, for instance in Spain (Dowson and Aten 1962).

The geographical range of the date-palm as a plant is much wider than that of its successful fruit production, as the tree can survive without damage, temperature extremes varying from -15° to 50°C. For its commercial culture, however, it needs a certain amount of heat, rainless periods during pollination and ripening seasons, and a sufficient water supply. These particular requirements have led the Arabs to indicate the needs of the date-palm by their famous saying: 'Its feet in running water, its head in the fire of the sky' (Ghamrawy 1930).

The date-palm can tolerate high but not excessive salinity as the latter condition will reduce its growth and will result in fruits of inferior quality. The greenhouse experiments of Furr and Ream (1967), showed that the growth of young Deglet Noor and Medjool seedlings was adversely affected by the increase of the salinity level from 4-8 to 16-24 mmhos/cm at 25°C. The high salt tolerance of the date-palm is attributed to the ability of the tree to exclude the chloride ions in the process of water absorption from a highly saline soil (Furr and Armstrong 1962).

Except for breeding purposes, where some seedlings may prove to be of good quality and consequently a new variety may arise, well established commercial date varieties are best propagated from offshoots, preferably those formed at the base of the trunk. Bull (1961), Lefèvre (1962) and Wertheimer (1956) have shown that age, size and weight of suitable offshoots are all varietal characteristics. Experience and care are required for the proper separation of offshoots from their parents to

ensure a high percentage of survival. However, a high percentage of mortality frequently occurs which may be attributed to the offshoots being planted very young, irrigated with excessively saline water, roughly handled, allowed to dry out, or attacked by termites as reported by Dowson (1963), Lefèvre (1956) and Wertheimer (1956). The offshoots can be grown in nurseries for about 2 years and then transplanted into the grove. They can also be planted directly in the grove at a spacing of 10 × 10m to allow sufficient sunlight and aeration. Closer spacing than necessary may result in a crowded grove with dates of inferior quality (Elbert 1965).

Many date growers, fully utilize the space between the date-palms by growing various fruit, field and cash crops. This practice may be justifiable from their own point of view as it may add to their net income. The main drawbacks of such a practice, however, are that the palms often do not receive the required attention to make their growing a profitable concern because of the assumption that the tree is a hardy one and does not need much care. Moreover, this practice may increase the humidity of the grove which in turn may encourage the development of certain diseases (Elmer *et al* 1968a). It is therefore, preferable to grow pure date groves, or, when mixed farming is the objective, it is best to grow each crop in separate rows, thus allowing each to receive its appropriate agricultural treatments.

Irrigation is a very important factor, but complicated due to the fact that the date-palm does not react to water stress by wilting. Therefore, the water requirements of the date grove must be properly satisfied. Under certain conditions, however, water can be withheld for 2 to 3 months before harvesting without any consequences to quality or yield. This promotes drying of some soft varieties, and reduces fruit drop in humid regions (Nixon 1966).

The date-palm requires proper amounts of fertilizers, especially in sandy soils. It generally responds well to N-fertilization, but it does not need an abundant N-supply for maximum yield as do other fruit crops.

The date-palm is dioecious, so that mixed planting of male trees with female trees is necessary; a single male tree can provide about 50 female trees with enough pollen. (Bomhard, 1963; Haas, 1963).

Controlled pollination between selected palms largely determines the quality of the fruit. Therefore, if artificial pollination is not properly done, dates will be mostly of low quality. The efficiency of pollination is largely influenced by various factors, such as the amount of pollen used, viability of the pollen, receptivity of the female flowers and the weather conditions prevailing during pollination viz. temperature, rain and wind (Furr and Ream 1968). The process itself varies according to countries and traditions. It is to be noted that pollen may be collected from the desired male inflorescences, dried and stored, until it is required. The pollen may then be dusted directly on the female flower, or applied on a cotton wad and placed between the strands of the female clusters (Nixon 1966). A small portable sprayer fitted with a long tube may be used, as reported by Wertheimer (1957), for pollinating the trees from the ground.

There are hundreds of date varieties, but only very few have real commercial value. The varieties are classified into soft, semi-dry and dry. Soft varieties do not keep well, do not need much heat for ripening and are eaten fresh; such as Halawy, Khadrawy, Sayer (Iraq), Saidy (Libya) and Hayany (Egypt). Semi-dry dates such as Zahdi (Iraq) and Deglet Noor (Algeria and Tunis) need more heat to ripen than do the soft ones. They keep well after proper drying and are much in demand. Dry dates such as Thoory (Algeria) require a great deal of heat for ripening. Dowson and Aten (1962) report that the Büdandalu or Haseku date variety from Iran is the only seedless one.

There are many different terms denoting the degree of date ripening. However, the stages of maturity in dates have been generally assigned to the following 4 popular terms as outlined by Dowson and Aten (1962):

1 the 'kimiri', i.e. the green fruit, stage,

2 the 'khalaal' stage, which includes full size dates changing in colour to red or yellow.

3 the 'rutab' stage, which is characterized by a discolouration process to shades of dirty brown or black, and by a squashy texture and loose skin,

4 the 'tamar' stage, is the last stage of maturity and is considered as representing the perfect condition for keeping the fruit without spoiling.

Yields differ greatly according to variety, the environmental conditions under which the date-palm is grown, and the proper management of the grove. So, whereas an adult tree which is well-cared for can yield as much as 100 kg of dates, a neglected one may yield less than 20 kg (Dowson 1961).

The pests and diseases of the date-palm are numerous inspite of the fact that the ecological conditions under which the palm is grown would appear to restrict their development. Brun and Laville (1965), Calcat (1959); Kehat and Swirski (1964), Laville (1962), Lefèvre (1956), Martin (1958), Perau-Leroy (1954), Toutain (1965) and many others have reported various pests and diseases infesting the leaves, crown, bud, trunk, fresh or stored dates. Elmer *et al.* (1968b) reported that the 'bayoud' disease caused by *Fusarium oxysporum* var. *albedinis* is among the most important diseases and though at present confined to Morocco and south-east Algeria, constitutes a threat to date-palms everywhere. It was responsible for the destruction of 10 million palms in Morocco, including most of the trees of the best commercial Medjool variety. It was further reported that henna bush (*Lawsonia inermis* L.) and lucerne (*Medicago sativa* L.) which are often grown among date-palms are symptomless carriers of the fungus. Mites, various species of date scales and beetles, moths and aphids are some of the most important insect pests of dates. It is worth mentioning that some predators such as *Nitidulideae* and *Coccinellidae* species may be used as a biological means of controlling certain insects such as the Parlatoria Date Scale caused by *Parlatoria blanchardi* (Targioni-Tozzette).

Harvesting of dates is greatly influenced by the prevailing climatic conditions under which the date-palm is growing; under optimum conditions, dates can be left on the palm

till they are fully mature; but under marginal climatic conditions, when a high humidity or a low temperature prevails, dates do not fully mature on the palm and they are, therefore, harvested before they reach full maturity and are subsequently artificially ripened or processed. Processing, therefore, is a term used to denote all treatments given to the dates after being harvested and which result in changes in their chemical composition, colour, shape, size or texture (Dowson and Aten 1962).

Processing takes place either in the field or in specialized packing houses. The field processing or the artificial ripening and curing of dates differ according to the traditional practices obtaining in any date growing country. Dates in the 'kimri' stage are hardly ripened except in Makran (W. Pakistan), where they are mashed in a basket and then transferred to an earthenware jar. Giani (1956), reported that the product can only keep well for 2 days because of the low sugar and high moisture contents of the product. The main object of ripening 'khalaal' dates is to reduce their moisture content to about 20%, unless they are to be preserved with a higher moisture content. In sunny areas, fruits are spread out in the open for a few days, but in areas with unreliable sunshine, dates may ferment before they are properly ripened; therefore, they are cut into halves to accelerate drying. In Australia, where rainy weather prevails, Richardson (1952) reports that the whole bunch is severed and the cut end immersed in water, with normal ripening of most of the dates resulting. Dates can be ripened by means of acetic acid or sodium chloride solutions (Nadda and Hassan 1955; Samish *et al* 1957). 'Khalaal' dates are sometimes not ripened or matured, but preserved directly in date syrup or by cooking. Whole dates as well as sliced ones are preserved in syrup (Dowson and Aten 1962; Giani 1956). Dates are boiled in ordinary water for a certain time and then allowed to dry till they are hard and wrinkled: they can then be kept for long periods, as mentioned by Carlson (1960). Some soft date varieties can also be preserved in jars or cans after being enriched with vitamin C (Ragab *et al* 1955).

Under favourable climatic conditions, dates are usually cured on the palm into the 'tamar' stage, in which they can either be packed without any further drying, or stored till they are sold or packed. In areas where heat and humidity are marginal, dates on the palm reach the 'rutab' stage only, so that they have to be cured into 'tamar' dates in the sun or by artificial means.

Superior quality dates are commercially packed in packing houses, where approximately the same principles as are applied in field processing are followed, albeit by making use of mechanical means. Dates are usually fumigated with methyl bromide, once in the field before they reach the packing house, where upon their arrival they may receive a second fumigation. Dates are sorted out to eliminate culls and refuse, and to separate them into grades with uniform ripeness, consistency, size and appearance in order to obtain a uniform product for further handling. They are then washed, drained-off, steam-hydrated at a certain temperature for periods dependent upon the moisture content and the maturity of the fruit, cooked and packed into a variety of suitable packages. Maier (1963) observed that the processing procedure may differ in some aspects such as the temperature used for steam-hydration and the inclusion or omission of a preserving agent against microbial spoilage.

Dates are packed differently in the field in different countries according to tradition. The main principle involved, however, is to press the dates into baskets or other suitable containers, varying from dried goat or sheep skin to petrol tins, to exclude most of the air. These packed dates are sold either locally or in neighbouring markets. The products of such packing are not hygienic, are easily contaminated with dirt and insects and are difficult to handle, the fruit being transformed into a syrupy mass.

Dates can be kept in cold storage either before or after processing (Winter 1956). Cold storage will preserve dates for periods depending on the moisture content of the fruit and on the degree of cooling (El Shiati *et al* 1959; Heikal *et al* 1959; Salama 1959). Lutz and Hardenburg (1968) pointed out that cold storage of dates with unduly high moisture content, renders them liable to microbial spoilage such as yeast fermentation and moulding, and to physiological deterioration including darkening and loss of flavour and aroma.

The date-palm, next to the coconut palm is the most valuable tree to man. Dates, being a very rich source of energy constitute a staple food in many developing countries. *Per capita* annual consumption in these countries may amount to 48 kg as compared with only a few hundred grams in the developed countries where the date is considered a delicacy. Every part of the tree is used and many by-products are obtainable from the fruit. The date as a commodity contributes largely to the economy of some countries and is a good source of hard currency.

Some important by-products are prepared from dates of inferior quality such as date-syrup, date-paste, jams and marmalades (FAO 1962). Munier (1961) and Schiller and Maier (1959) prepared date nut spreads which are a combination of finely ground dates with groundnut butter, ground almonds, walnuts and groundnuts. They can be used as sandwich or cracker spreads or as cake decorations and pastry fillings. The same authors reported the preparation of puffed-dried date powder which can be successfully incorporated into jelly confections or can be utilized by the baking industry; as well as jellied candies and chocolate coated date bars. Dates can be also fermented and distilled into vinegar or alcohol and the waste from the fermentation process can be used as a fertilizer. Treakle (1965) mentioned that oil for the soap industry can be obtained from ground date stones.

A simple water extraction of the natural sugars of the date fruit is the main principle involved in the manufacture of date syrup. Pitted and coarsely ground dates are mixed with water, heated to a certain temperature, filtered and concentrated under vacuum to a desirable consistency. Too high a temperature results in a dark poor quality syrup. Dates contain pectic substances which interfere with the filtration process, so that boiling, pH-adjustment and the addition of a filtering aid to the slurry is required.

A paste can be produced from clean dates which can be eaten mixed with milk powder, nuts, flour or fruits. Meat mincers are used in Libya to prepare such a paste with a good colour, and that does not harden, at a moisture content of about 20% (FAO 1960). Dupaigne and Munier (1965), prepared a good quality paste that can be marketed in Africa as well as in Europe and America. For the African market, however, the paste can be enriched with oils, protein-rich products and vitamins. Some mixtures of dates and/or date molasses with protein-rich products of low cost such as sesame, cotton seed flour, yeast or skimmed milk powder are highly palatable and acceptable. These products were recommended for use by the army, for school children and for the relief of malnutrition (FAO 1966).

Dates of very inferior quality can be used for animal feed by macerating and mixing with suitable concentrates such as ground barley and meals of sesame or other oil seeds. The digestibility is good and it can produce very satisfactory and economical rates of weight gain in sheep and lactating dairy cows (Ali *et al* 1956a; 1956b). Date stone meal has also been used successfully as a substitute for barley in poultry rations (Affifi *et al* 1966).

Palm tapping is practised extensively in North Africa where a sweetish sap is obtained by tapping the trunk; the sap is used for preparing an alcoholic beverage or, as it contains sugars, (mainly sucrose) for the production of palm sugar either as molasses or in a crystalline form (Munier 1965). Careful tapping of the trunk may yield 200 to 300l of sap annually; by removal of the terminal bud the yield can be increased to 1,000l. It is, however, advisable not to tap the palm more than 2 to 3 times during its life, else a loss of about 5% of the palms may occur (Dowson 1957).

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Melons

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Summary

This paper deals with the cultivation of melons in Cyprus, with reference to other countries of Europe, and the Mediterranean region. The varieties of musk and water melons grown in Cyprus are described in some detail and the advantages and disadvantages as well as the potential of each variety are pointed out.

The present production, local consumption and exports are discussed, and suggestions on how to build up a better export trade are made.

Emphasis is given to the need to concentrate on the production of early varieties, thus making full use of Cyprus' climatic advantages over its European competitors; the need for establishing a marketing organization to deal with exports; and to a change towards varieties that are in higher demand in the UK and other European countries.

The paper also gives a short account of the methods of cultivation and harvesting, and outlines existing regulations on export, grading and packing.

General

Cyprus is the third largest island in the Mediterranean, having an area of nearly 9,324 square kilometers (3,600 sq. miles). It has a typical Mediterranean climate characterized by hot dry summer, and fairly cold rainy winters. On the highest peaks of the mountains (1,500 m) there is snow for about 1-2 months of the year. In the plains snow is a very rare phenomenon, and along the coastal plains winters are even milder, thus allowing for early production of melons and vegetables in general, especially under plastic covers.

The hot summer climate of Cyprus is ideal for the production of melons. The main crop is confined to the north-west plain of the Morphou region, and on the alluvium south of Larnaca town. In the first region soils are of alluvial origin near the sea, and of the Terra Rosa and Red Earth type further inland. Melons are also grown all along the various coastal plains. It is thought that melon cultivation in Cyprus dates back to the 19th century, with Turkey as the most likely country of origin. Intensive cultivation of melons in Cyprus started in 1940 and as from 1950 small quantities were exported to UK. The total area under melons is around 1,200 ha more or less equally divided between water and musk melons. Both crops are grown under irrigation, except for a very small acreage, in certain coastal regions with sandy soils and high water-table, where watermelons are produced without irrigation.

Melon Producing Countries

Melons may be distinguished into muskmelons and watermelons, which belong to the same family Cucurbitaceae. Three varieties are of economic importance; these are the Cantaloupes, the Smooth-Skinned and the Netted muskmelons. Melons are important fruits for the international trade, and the most popular varieties weigh 2-3 kg. (5 to 7 lb.) with a diameter of 15 cm–20 cm (6 to 8 inches).

Among the leading melon growing areas one could mention California, where considerable work has been done for developing varieties resistant to disease with

good transport properties and of good quality. In Europe the cultivation of melons is concentrated in the Mediterranean region, with France and Italy being the leading countries. There the greater part of the crop is locally consumed. Italy exports mainly to continental European countries, and France exports Charentais muskmelon to the United Kingdom from July to September.

Spain is one of the largest muskmelon producing countries in Europe, and exports most of its production to UK for almost nine months a year. Almost 75 per cent of the British imports of melons come from Spain. In the last six years or so, this has been at the expense of imports from France, Israel, the Netherlands, and Cyprus (Anon, 1966a).

Bulgaria, Hungary and Yugoslavia are also large growers of melons. Hungary exports watermelons to UK in August to September. Israel produces large quantities of an out of season muskmelon, the Ogen, which is mainly absorbed in the United Kingdom market, at a high price. Holland is growing Ananas muskmelons under glass, for export to UK, Belgium and West Germany. This variety is available from June to August. The Canary Islands supply the UK market with Oren muskmelons from March to July.

Cyprus is a large producer of muskmelons, although the greater part of the crop is consumed locally, but is one of the main suppliers of watermelons to the UK market.

Production and Export of Melons in Cyprus

The total area under melons is around 1,200 ha which varies from year to year, depending on the availability of water in the spring from spate irrigation. Since in Cyprus the limiting factor is irrigation water and not land, the area under melons every year will vary with the acreage of other annual irrigated crops, their possible prices and anticipated demand. Melons occupy less than 5 per cent of the total irrigated land: citrus and potatoes are the main irrigated crops occupying about 40 and 30 per cent respectively, while vegetable and other annual crops make up the balance of 25 per cent.

Although the area under melons has remained practically constant during the last 10 years or so, production has nearly doubled due to better cultural methods, and is now estimated at around 40,000 tons annually. In spite of increased production, a definite decrease in the export of muskmelons has been observed in recent years, while that of the watermelons remained fairly constant, according to the Commodity Reports of the Cyprus Ministry of Commerce and Industry indicated in Table 1.

Cyprus melons are exported mainly to the United Kingdom with smaller quantities to the Federal Republic of Germany, Sweden, Denmark and Lebanon. Exports of melons start in June and extend to October. The main variety of muskmelons exported is Honeydew; of watermelons, Malali and Chilean Black Seeded, which are exported in refrigerated ships. During the last two years small consignments of Haogen and Sugarbaby were exported by air.

Table 1
Total Annual Exports in Tons

Year	Watermelons	Muskmelons	Total
1961	784	2522	3306
1962	1487	3177	4664
1963	961	1042	2003
1964	1129	994	2123
1965	953	1032	1985
1966	588	681	1269
1967	1364	256	1620
1968	1167	181	1348

The reason for the decline in the export trade may be attributed mainly to the following factors:

1. The Cyprus muskmelon variety yellow Honeydew has been losing ground from the time that Spain started producing and exporting a better variety, the green Honeydew. This of course has affected Israel, France and the Netherlands as well. The lower and unsteady export demand forced Cyprus farmers to reduce their Honeydew melon acreage, in favour of other varieties more popular in the local market.

2. The high airfreight charged for the more perishable varieties such as 'Ananas' makes it difficult for these varieties to be exported when ready in June, as at that time Cyprus cannot compete with Spain and France, as regards prices.

3. Lack of continuity of supply is another important factor that has had an adverse effect on the trade. The reason for this is that the high cost of production of summer grown melons due to irrigation, makes it impossible to compete with the low prices at which these commodities are offered at that time.

4. The absence of a suitable marketing body which could secure markets, cheap airfreight, continuity of supply and at the same time offer guidance to the growers on the varieties required and the desirable presentation, grading and packing, is another serious handicap.

The most popular varieties of muskmelons grown in Cyprus are the following:

Yellow Honeydew or Yellow Canary. A medium early variety, oblong in shape, with a tough rind, partially ribbed. The flesh is creamy white, juicy and of good taste. Its keeping properties are very good. It is grown extensively in Cyprus for the export trade, which starts in June and extends to October, the peak export period being July-August. It is shipped in ventilated compartments.

Ananas. A medium early variety, oblong, with netted rind. The flesh is creamy white, very sweet, with a strong aroma. This variety is very popular locally but has poor transport properties. Small quantities are exported, either by air or in refrigerated ship compartments from August till October.

Argitico. This is a late variety, originally introduced from Greece where it has a great reputation. It is named after the town of Argos where the melon developed.

The fruit is oblong and partially netted. The flesh is salmon pink in colour, juicy, aromatic and sweet. It is exported in small quantities in refrigerated ships in late August.

Tamboura. This variety has been grown in Cyprus for many years. Its fruit is round, with smooth skin, which turns orange green upon maturity. The flesh is yellow-white, juicy, aromatic and sweet. Its weight is around 2–4 kg (5–8 lb.). It is the earliest variety on the market and always fetches high prices. Selection work is essential as this variety has been in use for so long that it has gradually degenerated. Its transport properties are rather poor.

Ogen. The fruit is small, round and ribbed with thin rind, green in colour, turning orange green on maturity. The flesh is apple green, very sweet and juicy with a strong aroma. Its transport properties are poor and it is thus exported by air. This variety was introduced from Israel, and is grown under cover, mainly in the coastal areas, where the fruit matures in April–May.

The following are the most important varieties of watermelons grown:

Malali. A late variety, round in shape with medium thick dark green rind. The flesh is red, rather sweet, with many seeds. The average weight is between 2.5 kg.–4.5 kg. (6–10 lb.) but fruits weighing up to 16 kg. (30 lb.) are often produced, then are used locally. Its transport properties are good and it is exported by ship in ventilated compartments.

Chilean Black Seeded. A medium early variety introduced from California, with round fruit of uniform size up to 6 lb. The rind is medium thick, dark green, with darker stripes. The flesh is juicy, sweet, and bright red in colour, with small black seeds. It is gaining in popularity in the local market.

Sugarbaby. This variety was introduced from California a few years ago for growing under cover, for the export market. The fruit is round, weighing up to approximately 3 kg. The rind is medium thick deep green with darker rather inconspicuous stripes. The flesh is smooth, bright red in colour and sweet with seeds that are brown mottled black and small.

Method of Cultivation

The seed is planted in hills at approximately 1 m intervals in rows approximately 2 m apart. The plants are thinned to one or two per hill. Two to three hoeings are performed, to keep the crop clean from weeds until the vines cover the ground.

Nitrogen and phosphorus are used, as trials in the past have shown that the majority of the soils of Cyprus are fairly rich in potassium; 27–36 kg. (60–80 lb.) of nitrogen per acre are used; half is placed at planting time and the rest when the runners start, with 27–45 kg. (60–100 lb.) of phosphorus per acre are applied at or before planting. Some growers apply animal manure when this can be secured at reasonable prices; chemical fertilizers are then proportionally reduced.

Protected Cultivation

For the production of early melons in the warm climate of Cyprus, where protection is essential only for two to three months, the tunnel system is used. This involves temporary constructions of wire arches, placed in the ground at regular intervals, which support the plastic (PVC) sheets.

The seed is sown *in situ* from early December until February. An earliness of up to 40 days is achieved with some varieties of melons, which is of great economic importance. This method, however, is costly in labour, as the crop has to be covered and uncovered often for the cultural operations, and aeration of plants. Efforts are being made to modify this method to reduce labour costs. Early melon production with this method is most successful in the coastal plains.

Pests and Diseases

The most common pests that attack melons are, aphid *Aphis gossypii,* (Glov.) lady bird betele *Epilachna chrysomelina* (F.), melon fly *Myriopardalis paradalina* (Big.), the thrips *Bemisia tabaci* (Gennadius) and redspider mite, *Tetranychus telarius* (L.). These are controlled by various insecticides, such as Malathion, Parathion and Sevin. *Tetranychus* which is rather a serious pest, is controlled by chlorobenzene, etc.

The most common diseases are the powdery mildew, *Erysiphe cichoracearum* DC. which is controlled by sulphur or carathein dusts; alternaria blight *Alternaria cucumerina* (Ellis and Everh) Elliot treated by maneb or zineb and fusarium wilt *Fusarium oxysporum, f. melonis* (Leach and Currence) which is very serious in certain areas of the island. Soil fumigation, and the growing of resistant varieties are recommended (Anon, 1966b).

Harvesting and Grading

Harvesting of muskmelons is done early in the morning, at the 'half slip' stage, i.e. when half of the stem tears loose. There is no way of determining with certainty when watermelons are ripe, and harvesting is based on the experience of the growers. Some believe that when the fruit is thumbed and gives forth a dull sound, it is mature. Other criteria are the colour of that part of the fruit that touches the ground, which takes a yellow tinge as maturity approaches. The drying of the tendril at the point of attachment of the fruit stem to the vine, is also considered a sign of maturity.

Yields obtained under Cyprus conditions are as follows:

Table 2
Yields of Melons

Crop	Tons per hectare
Muskmelons, early	25–30
,, maincrop	32–37
Watermelons, early	32–34
,, maincrop	39–44

The crop intended for export is placed in lined containers to prevent bruises, which make the fruit susceptible to decay. From the field, melons are carried to the packing houses where these are graded for size and packed in suitable containers. Here they undergo inspection by the authorities. Grade specifications for muskmelons, referring to the containers and to the quality of the fruit are laid down by the Ministry of Commerce and Industry, as follows:

"No melons shall be passed for export, unless they are in sound condition and true to variety. They must be fully developed, ripe but not over-ripe, substantially free from melon fly, *Myriopardalis pardalina* (Big.), and other pests and diseases, bruises, cuts injuries or other blemishes, detrimentally affecting their appearance.

Melons packed in the same container shall be approximately of the same size, colour, shape and appearance and shall be of the same variety.

Melons shall be packed in cases, trays or cartons of a type and capacity approved by the Director and shall be protected to the satisfaction of the inspector, with woodwool, paper or similar material.

The containers shall be marked with the number of fruits contained therein. The variety and any other information required should also be well defined."

Melons are perishable commodities, some varieties more so than others. Early varieties have to be airfreighted, while green Honeydew and Malali can be transported in aircooled vessels. For these reasons, the export of melons needs to be highly organized, the creation of a suitable Marketing Board could greatly assist the trade. Such an organization would undoubtedly investigate the prospects of better packing and presentation which are of great importance.

As regards water melons, Cyprus, Israel and Hungary are the main suppliers to the United Kingdom market in July, August and September. Cyprus has the advantage of Commonwealth preference. From various reports obtained, however, it seems that the Cyprus watermelons Malali and Chilean Blackseeded are not greatly liked in the United Kingdom and are mainly consumed by immigrants from Cyprus and Poland. Even so, it is believed that with better presentation, existing exports may be maintained until better varieties are produced. Sugarbaby seems to be favoured amongst the British population, especially if exported early in May before any other watermelon reaches the United Kingdom market. The presentation of musk and watermelons is of primary importance, especially with the present competition and the aim must be the improvement of packing and grading.

Summary and Conclusions

Cyprus is a country in which melon cultivation can expand considerably, because of suitable climatic conditions. The decline in the export trade in the past 7 years or so, in spite of increased production due to better cultural methods, has been offset by an increase in local consumption. It is obvious that this increase cannot continue indefinitely and means have to be sought to increase exports.

The main advantage that Cyprus possesses over its European competitors is the mild winter climate which allows for the production of early melons under plastic covers at a reasonable cost. Israel, with a more or less similar climate, is very successfully moving towards this direction by producing the variety Ogen, which is exported to the United Kingdom market from March to May. In this respect particular attention has to be paid to grow the varieties that are in demand in the foreign markets. Such varieties are the Haogen, which is similar to the Ogen and the watermelon Sugarbaby. Plantings have to be arranged in such a manner so that continuity of supply for the whole of the early season may be maintained.

For the main season crop which is planted in spring, there is room for change into more suitable varieties like the green Honeydew, in preference to the yellow one. This is also being done in Spain. Cyprus has the advantage of earlier production but the disadvantage of higher freight costs. For later plantings Cyprus is at a disadvantage because there are also the higher costs of production arising from irrigation.

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Mango growing

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Summary

Commercial mango production is being stimulated, particularly in South Africa by recent advances in vegetative propagation of improved cultivars, the development of more sophisticated markets and reductions in airfreight costs.

Mangoes require a subtropical climate with an elevation below 600 meters. Hence, a warm autumn, a dry frost-free winter and a hot summer with a minimum of 800 mm. rain or supplementary irrigation is required. Slightly acid and sandy soils are preferred, although mangoes are not at all fastidious.

The fibreless, highly coloured, mildly flavoured Florida cultivars such as Kent, Zill, Irwin and Tommy Adkins, with their good carrying qualities and prolific bearing habits are superceeding the fibrous polyembryonic varieties, although 'Peach' is still in demand.

Double planting at 5 metres X 10 metres with subsequent tree removal avoids detrimental overcrowding. Fertilizer treatments are still based on citrus practices except that nitrogen levels are reduced in order to prevent excessive vegetative growth at the expense of fruiting.

The major disease is *Colletotrichum* (Black Spot) which is controlled by regular Dithane sprays commencing at blossom, followed by neutral copper sprays nearer harvesting. Blossom powdery mildew (*Oidium*) is controlled by the addition of Karathane to the initial spray, or by copper-sulphur dusting.

Spray residues and dust can result in an excessive build-up of the normally biologically controlled scale, necessitating the application of Summer Oil at 1.5% - 2%.

In spite of the problem of marketing immature fruit, harvesting when fruit reaches the 'mature green' stage allows the longest shipping period. Holding temperatures of around 13°C. are preferred, but riper fruits tolerate lower temperatures down to the commercial 8°C. Airfreighted fruit, packed in single layer trays or cartons, is rapidly gaining acceptance in Europe. Although still in the experimental stage, sea-freighting could drastically reduce costs. A wide market in Europe for good quality mangoes, intelligently merchandised, is anticipated.

Introduction

The consumption of exotic fruits in Europe has increased tenfold during the past five years, partly due to a reduction in airfreight costs on north bound flight routes. Up to now the proportion of this boom enjoyed by mangoes has been small, but as mangoes are one of the premium fruits of the tropics, their popularity with the European consumers should grow.

Although the mango has been cultivated in India for 4,000 years, it has been only comparatively recently introduced to modern horticulture, and the full story of its domestication and development is largely still a matter of speculation. To quote from Haynes (1945): 'on few horticultural subjects has more been written on less experimental evidence than in the case of the mango'. The mango, has benefited from agricultural progress and new cultivars have been developed which produce more fruit, superior in appearance, texture and shelf-life, to the stringy, turpentine-tasting traditional mangoes. Improved vegetative propagation methods, along with better fruit, have done a great deal to enhance the economic possibilities of the mango on the expanding world markets. (Popenoe, 1927).

Description

The mango, *Mangifera indica* L. (Anacardiaceae) originates from the Asian monsoon regions but is now distributed in the tropical and subtropical lowlands throughout the world. (Singh, 1960).

The Fruit

The luscious mango fruit is brightly coloured and has a melting, orange-coloured flesh. The sweet, slightly sub-acid taste is combined with a delightfully distinctive aroma and spiciness unequalled in fruit of the temperate regions. The unpeeled fruit can be cut lengthwise, the two halves twisted to pull them apart from the stone,

and served in the half shell. A multitude of recipes describe how this unique and versatile fruit can be prepared fresh, canned, pickled, cooked, frozen or dried. It can be used when green, half ripe or fully ripe. An excellent mango flake breakfast-cereal is being made in India. Quick freezing by the liquid nitrogen process is extremely successful thereby opening up a further potential outlet.

Varieties

It is generally considered that there are three main types of mangoes.

The fibrous poly-embryonic seedlings originating in the West Indies and South America, but now occurring throughout the world. These bear poor quality fruit with a distinct turpentine flavour.

The Indo-Chinese type which originated in the Philippines and Indo-China are also poly-embryonic but with fibreless, sweet-tasting flesh. These generally lack attractive colouration and are mostly poor bearers however are relatively resistant in anthracnose.

Indian types are the most important commercially. There are over a thousand cultivars in India, each being adapted to a specific locality. They are often highly coloured and fibreless with a distinct aromatic flavour. The most famous variety is perhaps the Mulgoba which was introduced to the USA in 1889. A seedling of this variety growing at Cocoa-nut Grove in 1910 was named the Haden is looked upon as the 'Father' of commercial cultivars. The qualities were so outstanding that it stimulated the selection of additional first generation and subsequently, second and third generation Indian seedlings. From these selections, varieties have arisen possessing high enough qualities on which to base modern commercial production. Florida cultivars have proved to be regular heavy bearers of excellent external and internal quality fruit. They appear to be adapted to a far wider range of subtropical conditions. They have good shipping qualities and a long shelf-life. Of paramount importance is the ability these cultivars possess to ripen perfectly after being picked in the 'mature green' stage. Other varieties can only be picked when the ground-colour green, turns yellow, signalling the commencement of the ripening process. Predominant cultivars which are being commercially planted include Zill, Irwin, Tommy Atkins, Kent, Palmer and Keitt, listed in order of fruit maturation. It would be irresponsible to make universal cultivar recommendations as the position will always remain fluid as new cultivars emerge. Other varieties, however, worthy of mention and which are superseding Haden, mostly because of its erratic bearing habits, are Early Gold, Florigon, Lippens, Flascell, Davis-Haden, Smith, Carrie, Sensation and Edward from Florida; Nimrod from Israel, Malindi from Kenya, Kensington from Australia, Mabroka from Egypt. The South African 'Peach Mango', in spite of being fibrous, still enjoys a ready market. Well-known Indian varieties are, Alphonso, Pairie and Totapari. (Stephens, 1960).

Environmental requirements

The dominant factor in economic mango production which is confined to elevations of below 600m, is climate. It is limited to frost-free areas, young trees being killed by a temperature of 0.6°C., while older trees may tolerate slight frost for a few hours. Total rainfall or supplementary irrigation in excess of about 650mm are necessary but the limiting factor is the rainfall distribution pattern. As the mango requires at least five months of near drought conditions to ensure proper flowering and fruit-setting, economic cultivation is restricted to areas where there is a pronounced drought during the winter. Although temperature change can also provide this necessary growth check to induce flowering bud differentiation, it is the drought period in the mango's natural habitat which fulfills this function. (Van der Meulen 1969).

Vegetative growth and fruit production are largely antagonistic to one another: grafted trees bear precociously but do not attain the size of the more vigorous seedlings, which are poor bearers.

The mango is one of the least fastidious trees with regard to soil requirements, even tolerating waterlogged conditions. Slightly sandy soils are preferred as these allow accurate fertilization control.

Propagation

As the improved varieties are mono-embryonic, vegetative propagation is essential. The most suitable and universally used rootstock variety is Sabre. The seeds, removed from the husk, are planted in seedbeds, and are severely culled at the seedling stage. The selected seedlings are then transplanted into polythene bags containing a soil mixture made up of sand, soil and leaf mould in equal proportions, 3-2-1 fertilizer mixture, and enough dolomite limestone to adjust the pH to ± 6.8 (Young and Ledin 1954).

The nursery should be in semi-shade, and particular attention should be paid to judicious irrigation. Being poly-embryonic, several seedlings emerge from each seed and when the most prominent reaches approximately 20 cms. in height, the weaker ones are nipped off. When the plant reaches about 40 cm. in height it can be tip-grafted, using PVC grafting tape and the scion wrapped completely. Both stock and scion should be in flush and as few leaves as possible removed from the stock. (Oppenheimer 1958, 1968). After the second flush of leaves has hardened, the trees can be removed from the shade and hardened off. They are very sensitive to shock and when planted out great care should be exercised in retaining intact the ball of soil around the roots. (Nelson, Goldweber and Fuchs 1954 and Van der Meulen 1969; 1954).

Orchard layout

Standard orchard procedures are used bearing in mind that the mango is basically an external bearer. As soon

as trees touch, not only does yield suffer seriously, but the resulting humid micro-climate is conducive to disease. The best planting distance in an orchard of mature trees is 10m × 10m but as it takes up to 15 years for the trees to touch, the intervening space is utilized by initial double planting at 5 × 10m. Well before crowding occurs, every second tree is removed or topworked with the latest cultivars, affording the grower the opportunity to change his variety without disrupting production. Intercropping young trees is also an excellent practice.

Production

Hand hoeing and shallow discing are used to keep orchards weed-free or the weedkillers Diuron (Karmex) and Grammoxone may be used. Bromacil (Hyvar X) is extremely toxic and ought not to be used.

Irrigation, where necessary, should commence only after the onset of blossom, and cease after harvesting. It is preferable to give infrequent heavy irrigations, penetrating to about 1.2m, than frequent light irrigations. Although there is a surface-feeding root system, 3 or 4 tap-roots or 'droppers', penetrate deeply to supply the trees' water requirements.

On acid soils, dolomitic lime should be applied to bring the pH as close as possible to the optimum of pH 6.8. Young trees require at least four applications per annum of a balanced fertilizer with ample nitrogen to stimulate growth (Young, Koo and Miner, 1965).

When the trees come into production, nitrogen should be reduced to limit growth and stimulate bearing. An advisable practice is a split fertilizer application, the first half followed by a heavy irrigation as soon as the flower panicles are visible and the other half as soon as the crop has been harvested. The physiological disorders of 'Soft Nose' and 'Jelly Seed' are decreased by increasing potassium and calcium levels and increased by nitrogen. A rough guide to the quantity of fertilizer is the application of 0.5 kg. per tree, per year for every year of the age of the tree, rising to a maximum of 7kg. for older trees. A popular mixture is 4-1-6 or 3-1-5. Bearing trees should always suffer from a slight nitrogen deficiency. In addition 1.5kg. of magnesium sulphate per tree can be applied on full-grown trees. On calcareous soils, annual additional sprays of trace elements, especially zinc should be applied. (Hobson 1969; Campbell and Malo 1967; Ruehle and Ledin, 1960; Lynch and Mustard, 1955; Marloth, 1947; Hayes, 1945).

Flowering

The bloom panicle bears masses of small flowers, of which 1% to 20% are perfect, depending on variety and climate. Pollination is by insects. Unfertilized fruit with abortive seeds are sometimes set during unfavourable climatic conditions, causing the phenomenon of 'small fruit', which can seriously reduce the crop. Usually, one to three fruit ultimately set on each panicle.

Blossom disease

'Powdery Mildew' (*Oidium*) and anthracnose can wreak havoc on the blossom during damp weather. The standard control recommendation in areas, where black-spot spraying is unnecessary, is a sulphur-copper dust (Copsul) which is applied at the first signs of the onset of the disease, and in any event should be applied in the open flower when the blossom panicles are sticky with nectar. Alternatively, Karathane added to a black-spot spray is very effective.

Fruit disease

'Black-Spot'. The disease with the most serious economic consequence is black-spot, caused by a fungus, *Colletotrichum glocosporioides* Penz. The onset of the disease usually coincides with crowding in the orchard, and is accentuated by damp weather. The disease causes brown, watery spots on the ripening fruit turning black, and causing complete and rapid collapse, especially at warm temperatures. Control recommendations are the applications of fortnightly Dithane M 45 sprays, commencing at blossom. These should be continued until fruit is golf-ball size, by which time the rainy season should have begun. Subsequently, neutral copper sprays of 1.5% - 2% metallic copper are applied monthly till just prior to harvest. During dormancy, a clean-up spray of copper plus 0.5% emulsifiable summer oil is an added precaution. Wetting and sticking agents must always be added to mango sprays, otherwise the spray liquid simply rolls off the waxy leaves. (Conover, 1965; Ruehle 1953).

'Bacterial Black-spot'. Under unfavourable conditions disease caused by *Bacterium mangiferae* Doidge, attacks the fruit, and lesions may even occur on leaves and twigs. The disease manifests itself as a hard, scab-like black-spot on either green and ripe fruit. The infected patch cracks open and gum exudes, and eventually the fruit drops and decays. The problem needs much investigation as it is debatable whether control is possible. Copper appears to have some effect, but exact application times have not been determined.

Virus diseases

Mango 'Bunchy Top' disease is prevalent in India, Pakistan and Egypt. Although formerly considered a virus disease, it has recently been discovered in India that it is caused by a fungus *Fusarium moniliforme* (Sacc) Sheld. It is spread by mites, and can be controlled by spraying with a mixture of a fungicide (Captan 0.1%) and an acaricide. Symptoms are malformation and dwarfing of terminal buds and flowers. (Varma, 1967; Summanwar and Raychaudhuri, 1967).

Scale. Although numerous species of scale have been reported on the mango, only the mango shield scale *Coccus mangiferae* Green and the lesser 'Snow Scale' *Pinnaspis strachani* Cooley are troublesome. Spray residues, dust from roads and excessive discing of orchards, are conducive to the build-up of scale by discouraging natural predators. Generally it is completely biologically controlled, but should it get out of hand, it can be controlled by the application of Citrus summer oil sprays of 1.5% - 2% at 35Kg. sq. em. pressure. One should always adhere to normal safety precautions when spraying. (Wolfenbarger, 1963).

The Mango Weevil *Cryptorhynchus mangiferae* F. occurs throughout mango growing areas. It lays its eggs, on the fruit at about 'hen egg' size. The grub burrows its way into the seed where it develops completely hidden without affecting the flesh. During autumn, sometime after harvest, it emerges as an adult. It only presents a problem in very late maturing varieties and in late areas when it can emerge before fruit maturity, thus spoiling the fruit. Orchard sanitation is the best control measure.

Yields

Mangoes can be alternate and erratic bearers, so yields can vary greatly. The Florida cultivars are excellent bearers. Yields have been recorded such as 48 fruits on a three-year old Kent tree in South Africa. In Java, 1,000 to 1,500 fruits per tree is considered normal. In South Africa a reasonable orchard production is 30 trays per full-grown tree.

Harvesting

The crop is harvested over a period of about 3 months. There is a pronounced peak, which can vary by as much as a month from one season to the next. This can cause a marketing crisis and illustrates the necessity of varietal diversification to spread the crop as can be seen from Figure 1.

For distant markets, fruit should be clipped from the tree at the 'mature green' or 'hard ripe' stage, when the flesh of the cut fruit shows a change from white to yellow round the seed. The specific gravity should then be not less than 1.02. If picked earlier, the fruit will not ripen, so that immature and inedible fruit reaches the consumer (Harkness and Cobin 1950). Numerous pickings from the same tree are thus necessary. About 1cm. of stalk should be left on the fruit to prevent bleeding. Fruit out of reach can be picked with a special fruit-picker, having a clipper and small bag on a long pole. The pickers use picking bags for collecting the fruit which are gently emptied into lugboxes and transported to the packing shed.

Packing

After grading for size, external quality and maturity, the fruit is packed in standard single layer fruit trays, taking care to pack similar fruit in each box. Corrugated cartons are used for export. Fruit should be individually wrapped with plain wrappers; woodwool should not be used. To prevent detrimental heat generation of the ripening fruit, ventilation is extremely important, and pre-cooling to remove field heat greatly enhances shelf-life.

Storage

Cold storage requirements are highly variable depending on the cultivar, climate, maturity, cultural practices, etc. Temperatures range from 8°C to 13°C. The riper the fruit, the lower temperature it can withstand. Cold injury can generally be avoided if the latter temperature is adhered to.

Ripening

Mature green fruit ripen rapidly at 21 - 24°C but a better colour is developed at about 18°C. Ripening should thus be started at the higher temperature and then reduced to the latter while holding high humidity. Above 27°C, fruit develops 'off' flavours and mottled skin. Artificial ripening is assisted by the use of ethylene or the non-explosive Azetil gas (95% nitrogen + 5% ethylene) but little is known of this practice. (Hatton, Reeder and Campbell, 1965).

Transport

Presently mangoes are airfreighted to Europe, but from limited experience, indications are that sea transport from South Africa may become possible.

Marketing

As the crop is harvested during the southern summer, South Africa is able to market in the European winter when fruit is scarce. From South Africa sales to continental European Countries are made on an f.o.b. basis while fruit is usually marketed on consignment in the UK.

Conclusion

The most essential part of any farming is the marketing of the final product and growers must look to the fruit trade to fulfil this role. Based on its merits and marketed aggressively, there is no reason why the mango, justly called the 'Apple of the Tropics', should not attain the dominant position it derives in the exotic fruit trade.

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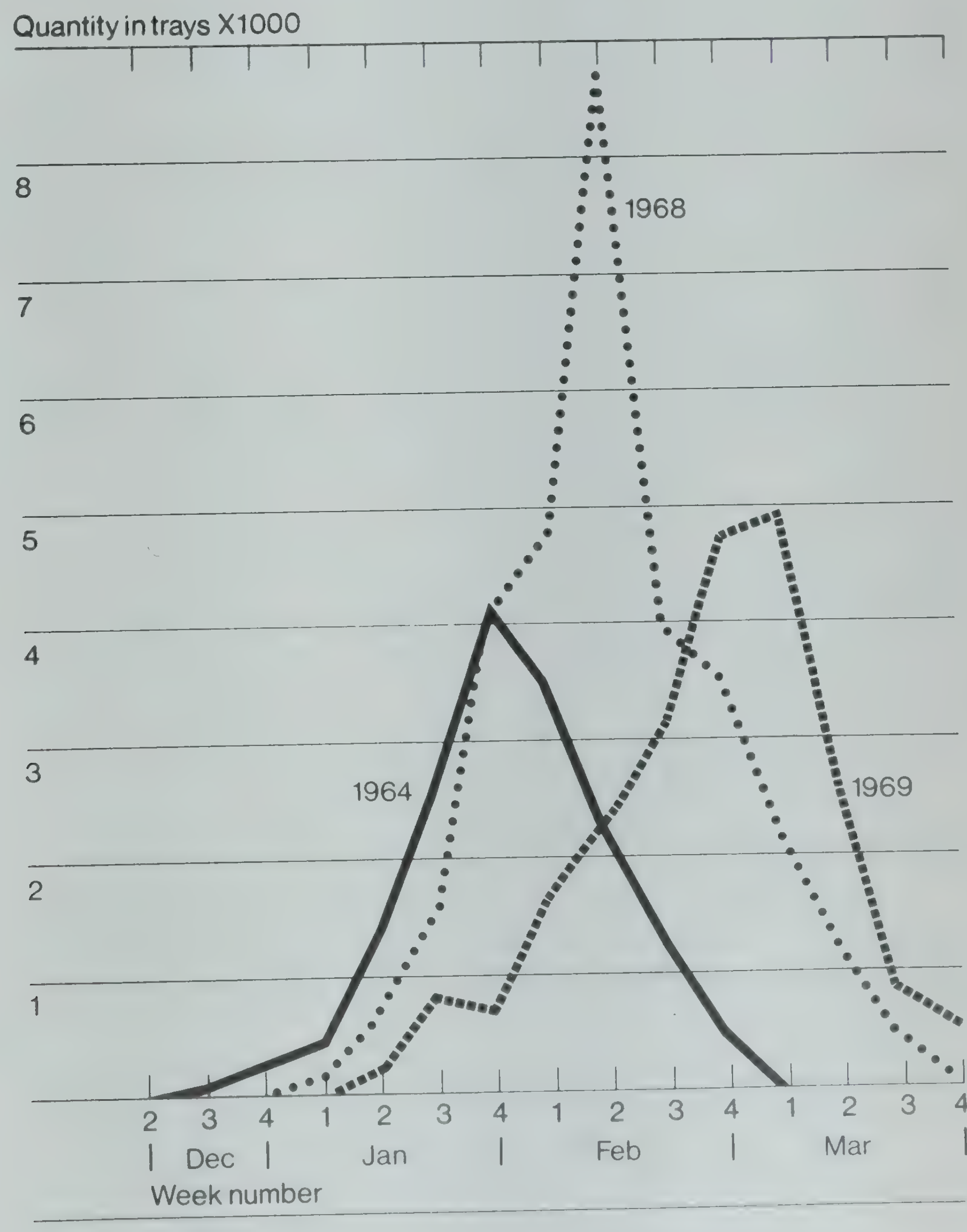
Figure 1
Mango weekly production



Problems of mango nutrition in calcareous soils

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Summary

Nutritional problems in mango orchards planted in calcareous soils in three semi-arid regions of Israel have been studied.

The main disorder was a lime induced chlorosis, and malformation of young shoots and leaves, culminating in death of the tree. Iron content of the affected tissues appeared normal, but application of an iron sequestrene to the roots corrected the disorder and enabled commercial growing of mangoes in these soils.

Three additional minor problems were:

Zinc deficiency which was regularly corrected by zinc sulphate or zinc oxide sprays.

Mild potassium deficiency symptoms, mainly in old leaves, which had decreased potassium content. Deficiency symptoms disappeared after the addition of potassium fertilizers.

Boron excess causing necrosis of older leaf margins and eventually abscission, was prevalent in loess soils. Boron contents of the affected leaves were abnormally high.

The mango is usually considered as being able to grow successfully on widely diverse soil types (Singh, 1960). Harloth (1947) has stated that soil type is hardly a limiting factor in modern commercial mango production in South Africa. Ruehle and Ledin (1960) credited the mango as being less affected by soil quality than any other fruit tree in Florida.

The range of soils considered suitable for mango growing explicitly includes calcareous soils. Ruehle and Ledin (1960) stated that mango will flourish on light acid sands as well as on alkaline limestone soils if properly fertilized. Singh (1960) in his exhaustive monograph on the mango, reported of successful mango growing on calcareous soils with up to 35 per cent CaO.

We have found in the literature only two instances when mango was explicitly reported to suffer when grown on calcareous soil. Agarwala and Mehrotra (1963) have mentioned the occurrence of mango chlorosis on such soils in Uttar Pradesh. Gandhi (1955) stated definitely that highly calcareous soils are considered too poor for mango growing because such soils are alkaline and burn the young plants soon after planting.

Calcareous soils are alkaline with a pH of up to 8.4. Singh (1960) concluded that mango can thrive very well within a pH range of 5.5 - 7.5, beyond which detrimental effects may follow. It can be inferred from the above statements that problems may be expected when mango is planted on real calcareous soils. Difficulties in mango development when planted on calcareous soils were noted in Israel 22 years ago (Oppenheimer, 1947), but the problem was fully investigated only in the last decade.

The main limiting factor in mango growing in Israel is climatic, or more precisely, the sensitivity of the mango to freezing temperature. Only limited, relatively frost-free areas are suitable for commercial mango growing. The mango was introduced to Israel some 40 years ago, and was planted experimentally in various regions that seemed to have suitable climate. It was found to grow well on the red-brown sandy-loam soil of the central coastal plain. This soil has a very low $CaCO_3$ content (less than 1 per cent) and its reaction is about neutral. In contrast trees planted in the Jordan valley did not develop well. Oppenheimer (1947) suggested that the factor responsible for this failure was the calcareous

soils. Climatic and soil requirements have for many years confined commercial mango growing to locations in the central coastal plain of Israel.

About 10 years ago a renewed effort was made to widen the area of mango growing. Small mango orchards were planted in three new, arid to semi-arid, regions having a favourable climate for mango growing:

The North-Western Negev, on deep sands covering loessial arid brown soils (Dan *et al,* 1962).

The Southern coastal plain, on light to medium dark brown soils (Dan *et al,* 1962).

The Jordan valley, on heavy, but well drained, colluvial alluvial soil (Dan *et al* 1962).

These orchards, like all mango orchards in Israel, were grown under full irrigation regimes.

The soils, in these three regions, differ considerably in their texture and origin, but all are calcareous, with $CaCO_3$ content of 10 - 25% and a pH of 7.8 - 8.4.

Severe nutritional problems have appeared in all these orchards, usually in the second year of planting: these include iron, zinc and potassium deficiencies and boron excess.

Iron deficiency

This was the most serious disorder encountered in all three regions. The most pronounced symptoms were unique and were not typical to lime-induced iron deficiency, as described in other fruit trees (Brown, 1956; Wallace and Lunt, 1960). At an early stage a light to medium chlorosis of young leaves appeared. Usually it was not the typical interveinal iron chlorosis; rather the whole leaf blade had a green-yellowish colour. As the deficiency progressed, young growth was severely affected. The new leaves ceased to grow before reaching full size, their final size becoming smaller and smaller. When the deficiency became very severe leaves grew to a length of a few mm and dropped. Concurrently the internodes shortened drastically. New growth thus became very weird in appearance as it consisted of many short leafless branches, with conspicuous scars left by the abscissed leaves. At this stage a gradual die-back of branches started, and if no treatment was given the tree eventually died.

Mineral analysis of the small chlorotic leaves revealed no deficiency (Table 1), but rather a pronounced increase in nitrogen, phosphorus and potassium levels and a marked decrease in calcium level. This situation is typical to lime-induced iron deficiency (Brown 1956). Frequently no apparent iron deficiency is found in the chlorotic leaves (Agarwala and Mehrotra, 1963, Malo, 1967, Wallace and Lunt, 1960), but the iron is mostly present in an unavailable form (Brown 1961, Wallace and Lunt, 1960).

As symptoms were not typical of iron deficiency, experiments conducted in order to correct the disorder included the use of zinc, manganese and copper in addition to iron. The following treatments were tried.

1. Sprays with 1 per cent iron, zinc, manganese and copper sulphates.
2. Application of 2 kg iron and zinc sulphates to the root zone of young trees.
3. Application of 100 - 300g iron sequestrene 138 (iron ethylene-diamino di-*o*-hydroxyphenylacetate) with and without the simultaneous addition of 1 kg $FeSO_4$.

The application of iron sequestrene 138 was found to be the only effective treatment. This iron chelate is considered as most effective supplier of available iron to plants growing in calcareous soils (Wallace, 1966, Wrigley, 1963). The addition of $FeSO_4$ with the chelate gave somewhat better results only in one of the treated orchards.

The effect of the iron chelate 138 was dramatic; healthy new growth burst from degenerate branches 3 weeks after treatment. When mature trees were treated at the beginning of the summer the new growth flowered profusely in the following spring and even yielded fruit.

It must be emphasised that the chelate has to be applied near active rootlets, otherwise it would not be effective. Mango tends to be deep-rooted and usually does not develop a root system near the soil surface. Good results were achieved when the chelate was applied in

Table 1
Typical elemental content of normal and deficient mango leaves.

Leaves condition and age	% dry weight							ppm dry weight				
	N	P	K	Ca	Mg	Na	Cl	Zn*	Fe	Cu	Mn	B
normal, 6 months old	1.7	0.10	0.8	2.2	0.4	0.08	0.2	170	70	8	60	60
small and chlorotic 6 months old	2.4	0.18	1.8	0.8	0.5	0.08	0.2	145	75	10	70	65
normal, 18 months old	1.3	0.07	0.4	5.2	0.4	0.10	0.3	200	80	6	90	100
green wedge, 18 months old	1.4	0.09	0.2	5.3	0.4	0.12	0.3	220	77	–	–	105

* trees were sprayed with zinc sulphate.

10 - 15 cm deep furrow dug around the tree trunk. In sandy soils it was sometimes necessary to apply the chelate even deeper, at a depth of 50 - 75 cm, in order to elicit a positive response in mature trees.

The optimal amount of chelate 138 was found to be 100 200 g per tree, high amounts being needed on heavy soil. The treatment has to be given every year and the best time for application is in April at the beginning of the growing season.

The annual amount of chelate 138 applied per acre (100 - 120 trees) is 10 - 20 kg., costing 80–150$ per acre. This appears very expensive, but as the mango fruit is a luxury item in Israel the extra expense for the chelate can easily be absorbed by the growers.

Several hundred acres of mango have been planted recently on calcareous soils, with up to 20% $CaCO_3$ content. Chelate 138 is applied regularly and development is entirely satisfactory. Commercial plantings of mango in soils having higher $CaCO_3$ content is not recommended. On such highly calcareous soils there is frequently a need for two chelate applications per year.

The regular application of chelate 138 appears to be an adequate short range solution to the problem of mango growing on calcareous soils in Israel. An inherently better and cheaper solution is the use of rootstocks which will enable mango growing on calcareous soils without the need for regular chelate applications. The polyembryonic Sabre variety was found to be a very good rootstock for the sandy-loam soil of the coastal plain (Oppenheimer, 1958) and it is now used extensively as a rootstock. However observations have indicated that some other rootstocks may be better adapted to calcareous soils. An extensive search is now being conducted for mango types, preferably polyembryonic, adapted to calcareous soils. Preliminary results seem promising.

It is an interesting question why mango usually grows well on calcareous soils in many parts of the world (Singh, 1960; Ruehle and Ledin, 1960) but suffers so much on calcareous soils in some places in India (Gandhi, 1955) and in Israel. This conflicting behaviour may be due to different calcareous soil types (Yaalon, 1954) or to the use of different rootstocks. Exchange of rootstocks between countries can help to solve this question.

Zinc deficiency

Symptoms of zinc deficiency in mango were described by Lynch and Ruehle (1940). Ten years ago this deficiency was found to be very prevalent in mango orchards in Israel (Oppenheimer and Gazit, 1961). As it can be corrected quite easily by spraying with $ZnSO_4$ (0.75%) or ZnO (0.2%), the mango growers tend to give an annual preventative zinc spray. As a result zinc deficiency symptoms are now only rarely encountered in Israel. Although alkaline pH is known to decrease zinc availability, zinc deficiency symptoms are not more prevalent in orchards planted on calcareous soils. Excessive phosphorus appears to be the main factor responsible for severe cases of zinc deficiency.

Potassium deficiency

Potassium deficiency tends to occur in calcareous soils (Reitemeier, 1951). Nevertheless only mild symptoms of potassium deficiency were encountered in one orchard on high yielding trees. Symptoms appeared mainly in old leaves of the preceding year's growth. The margins and tips of the affected leaves lost their green colour and subsequently became brown and died. A green wedge could be clearly seen in the leaf centre. These symptoms closely resemble magnesium deficiency (Smith and Scudder, 1951). Mineral analysis of the affected leaves (Table 1) showed potassium content to be low, at a level which deficiency symptoms occur (Smith and Scudder, 1951), while magnesium levels were normal. Potassium fertilizers were applied at 200 kg per acre per year and the symptoms disappeared.

Boron excess

Marked tip and margin necrosis of old leaves was found on trees growing on loessial soils in the arid North-Western Negev. Mineral content analysis showed that boron level in affected leaves increased from normal values of 50 - 100 ppm to 300 - 400 ppm and to 500 - 750 ppm in the necrotic tissues. Such high values indicate a case of boron toxicity (Bradford, 1966). The scorched leaves tended to drop, but as these are old leaves the trees do not suffer greatly.

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Mangoes and mango products

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Summary

Mango – *Mangifera indica* L. (Anacardiaceae) – grows wild in monsoon Asia and is extensively cultivated for its fruit in tropical and subtropical parts of Asia, Africa and America. Depending upon the locality of their cultivation mango fruits are available in the UK almost throughout the year and the imports could be regularized for development of the industry on a large scale. Different varieties of the fruit are used for juice, salads, jams, chutney, pickle, candy and other products depending on consumer requirements of both Western and Eastern countries. There may also be scope for the development of other industries based on mango.

The raw fruit is used for chutney and pickle, whilst the half ripe is used for jam and candy. There is no problem in picking, sorting, packing, handling or transporting of these in bulk to the UK by sea. The fruit must be shipped in the cooler parts of the hold, at an humidity below 30 - 40%. The fruit is washed in potassium chlorate, wiped dry of the acrid milky juice to safeguard against blackening or attack of fungi. Ripe fruit may be used for the table and for juice, fibrous varieties being good for juices and pulpy ones for jams and candies. Some varieties are picked fully ripe, or the fruits are allowed to ripen, whilst stored in straw during transport. Fruit for the table must be transported under refrigerated conditions. Many recipes for the preparation of pickles, chutney, etc. are known, but we would emphasize the necessity for research into the various preparations for the international market.

Introduction

Mango (*Mangifera indica* L.; Anacardiaceae) described as the king of Indian fruits, occupies more than 70% of the total area under fruit crops in the sub-continent from Cape Comorin to the base of the Himalayas, and from the Punjab to Assam. It grows wild in Monsoon Asia and according to the prevalent view is a native of the Indo-Burmese – Malayan Region. The only other Indian species *M. sylvatica* Roxb. grows wild in north-eastern parts of the country, but its fruit is not edible.

Although, the genus *Mangifera* has a large number of recognisable species; 41 according to Mukherjee (1949); 65 according to Hooker and Jackson (1895), most of the forests of wild mango and over a thousand cultivated varieties all belong to *M. indica.* The Indian varieties are mostly monoembryonic, propagated vegetatively by inarching. However, some varieties in the Punjab, Uttar Pradesh, and in other parts of the world are grown from seed. The fruit of these is highly fibrous and generally small in size.

Vegetative propagation of mango was started in India only about 400 years ago, though, the tree has been in cultivation for at least 4,000 years (De Candolle, 1884). The famous Stupa of Sanchi that bears sculptures of the mango tree and fruits is dated to about 150 B.C. and many Chinese and Central Asian travellers have mentioned mango in their chronicles. Mango appears in Vedic and Post-Vedic literature and has provided names for Kings, e.g. Amrapala; towns, e.g. Amrapura; and mountains, e.g. Amrakutta. In short, mango has been for centuries an integral part of the Indian people and their culture, in addition to being a delicacy for the rich and food for the poor. (Watt, 1889-96; Singh, 1959).

Mango is cultivated in many countries of Africa (Sethi, 1949, Marloth, 1947), America (Canizarea, 1950, Beach, 1910; Anon, 1922; 1932; Cruz, 1938; Fawcett and Harris, 1901; Kinman, 1918; Leon, 1938; Sturrock and Wolfe, 1944; Contractor 1949), the Pacific (Higgins, 1906) and, of course, all over South-East Asian region (Parsons, 1931; Anon, 1953). It flourishes in lowland tropical forest areas and here behaves like other tropical evergreen trees and shrubs (avocado, oranges, banana, papaya, etc.) in bearing two or three fruit crops in a

year. In the sub-tropical areas and up to the altitude of 3,000 ft. in the Himalayan region most varieties of mango bear one crop per year; and often there is only one good one every alternate year or once in three years. On account of its cultivation over wide geographical and climatic conditions mango fruits from different areas are available in UK practically throughout the year. Mango can be harvested in different stages of its growth, from quite raw to over-ripe; and in every stage of its growth fruit is palatable and has a desirable flavour and keeping qualities. These excellent qualities of mango have not been exploited to any great extent, commercially, by the food industry in Europe or America; and it is our feeling that given proper planning the mango-products industry can become one of the most important in the future economy of the developing countries of the Commonwealth, on the lines of tea, coffee, jute or rubber.

Cultivation

Mango is a large evergreen tree, adapted to tropical and subtropical climates and flourishes in areas with a mean annual shade temperature of 26°C (80°F) and a seasonal rainfall of 75 to 375 cm. (30 - 150″) per annum. Mango, especially young plants and while in flower, is susceptible to frost damage, but may tolerate high temperatures of over 42°C for several days. A dry pre-flowering period helps to induce copious flowering, pollination and in fruit-setting. Only a small proportion of fertilized flowers set fruits; usually about 1:150.

Mango grows on a wide variety of soil conditions, provided it is well drained and has a fair amount of humus. Extreme conditions of alkalinity, waterlogging, and/or nutrient deficiency are not suitable for mango. The plants do well both in coastal and inland areas, except on patches of black cotton soils and sandy substrata.

Most of the plants in cultivation are produced by shoot grafting of the superior variety on to a seedling root-stock, about one year old. Budding and root grafting have also been attempted with success. Hormone preparations like β-indole-acetic acid, β-indole-butyric acid and α-naphthyl acetic acid produce rooting in a number of mango varieties during the rainy season. Other methods like air layering and crown grafting also hold promise in quick multiplication of the stock of desired mango varieties. (Mukherjee, 1953).

The grafts are planted during the rainy season, depending upon climate and soil of the area at intervals of 10 - 14m in pits of about 1 × 1 × 1m. Young plants are frequently watered for the first 2 to 3 years. Super-phosphate and nitrogenous fertilizers encourage quick growth, though fertilization is seldom a problem in the Indian sub-continent; and too vigorous vegetative growth is not desired for fruitfulness. Farmyard manure mixed with castor cake, bone meal, ammonium sulphate or wood ash in varying proportions is used, depending upon the climate, soil conditions and the mango variety. Fertilization is, of course, done during early rains for best results. (Smith 1940).

Fruiting

Grafted mangoes start bearing about 4 - 6 years: full fruiting is attained in about 15 years, and lasts up to 50 years. Seedling mangoes take about twice as much time to come into fruiting but their bearing age is also doubled. The average number of fruits in good grafted varieties is 50 - 75 at the sixth year, rising to 300 - 500 in the 10th year and 1,000 - 1,500 at maturity.

It takes 4 to 5 months for the fruit to ripen after flowering. The time of flowering and fruiting follows a sequence from September - October in southern latitudes to March - April in northern areas. Thus, south Indian mangoes are in the market in February and the North Indian crop is ready in July. Ripe fruits are available in S. Africa in December; in Venezuela in March - April and at least twice in the West African countries.

Most grafted varieties are harvested raw and ripen in storage rooms at temperature of 20° to 26°C. Ethylene is successfully used for ripening in rooms where humidity is kept low.

Storage and Transportation

Ripe mangoes are perishable fruits and need great care in handling at all stages. Wrapping of individual fruits in paper, and loosely packing in straw in well ventilated baskets is generally adopted but much greater thought needs to be given to the problems of building up effective marketing in European countries.

Commercially desirable features for the location of an orchard include an easy access to road and port for quick transport, availability of cheap packing material and refrigeration facilities.

Commercially important varieties

As already mentioned more than 1,000 varieties of mango are known but not all of them are suitable for commercial production.

From India *Fazli* of Bihar, *Dusehri* of Uttar Pradesh, *Neelum* and *Bangalora* from the west coast, being regular bearing varieties need extensive exploitation.

The origin of most of the mango varieties is not precisely known. Some of the names are ambiguous, e.g., *Gulab Jaman* has nothing to do with the scent of rose or *Jaman*. The home of *George* or *Jailor* is not known, but *Fernandin* is believed to have been originated in Portuguese Goa. *Imam Pasand* and *Jehangir*, two of the best table varieties own their origin to the efforts of the Nawab of Masulipatnam in Madras. *Langra* is thought to have been discovered in the back yard of a lame faqir. The name *Alphonso* is used for a number of different varieties as – *Alphonso Batli* in Poona; *Alphonso Bihari* in Bihar, *Alphonso Punjab* in Punjab, *Alphonso Black* in Ratnagiri, *Alphonso White* in *Kanara* and *Alphonso Bombay* in Maharashtra.

Alphonso Bombay when cultivated in Mysore is called *Badami; Gundu* in Salem; *Patnam Jathe* in Tinnevelley; *Khadur* in Madras and *Appas* in Konkam. There is great confusion in the nomenclature of mango varieties and although Gangolly *et al* (1957) and others have attempted to present some order, it must be admitted that, except for half a dozen varieties, most others occur very largely in the imagination of mango lovers. Here, therefore, is a need for proper scientific research in order to make international mango production a success.

Mango Products

Most of the varieties of mango have their characteristic pleasant flavour. Raw fruits, before the development of stone, are picked and used for making chutney and pickle, but these have little keeping quality. The kernel is dried, roasted and eaten, especially in years of food scarcity as gruel. Mango fruit has medicinal properties (laxative, diuretic and fattening). Juice prepared from unripe fruit, after baking in hot wood ash, has a cooling effect and is used during hot weather in the North Indian region. It is also alleged to help curing cholera and plague.

The smoke of burning green leaves is used as a cure for throat troubles. Powdered kernel of some varieties of mango is used in medicines for asthma and diarrhoea. The resinous material exuding from the stem end of the fruit is mixed with lime juice and used for treating scabies. The bark of the tree contains tannins, which are employed in the leather tanning industry. The timber of the mango tree is used for various building pruposes. Mango is an excellent roadside and avenue tree for its shade, and millions of trees are planted in the Indian subcontinent every year during the monsoon. Mango is one of the three national trees of India, the other two being *Peepal* and *Banyan.*

Mango fruit

Ripe mango is a table fruit and thick fleshy varieties are suitable for this purpose. Mango purée is prepared from ripe fruits, chutneys from half ripe fruits and pickles from unripe fruits. Squash is prepared from over-ripe juicy varieties.

Appendix I gives details of recipes for mango products. The ingredients used are available on both the UK and North American markets.

Appendix I

Mango Pickle

Ingredients:
1 pound mango, cut into slices
¾ pt. mustard oil or groundnut oil
2 ozs. green ginger
½ oz. to ¾ oz. red chilli powder
1½ tsp. turmeric powder
A small grain of asafoetida (optional)
3 to 4 teaspoonful salt
1 oz. aniseeds
1 tsp. nigella (optional)
1 tbs. fenugreek seeds
6 to 8 green chillies.

Method: Wash, dry and slice mangoes. Scrape the ginger and slice thinly. Sift, clean and crush aniseeds, nigella and fenugreek seeds.

Heat the oil to smoking point, add asafeotida when slightly coloured. Crush with the back of the spoon. Add rest of the spices and ginger slices. Stir for 2 minutes. Remove pan from the heat and add mango slices. Mix thoroughly. Cool and store in a sterilized jar.

Naurattan Achar (Spicy mango pickle)

Ingredients:
1 pound peeled and sliced mangoes
6 button onions
6 to 8 gooseberries
¾ pt. mustard oil or groundnut oil
2 ozs. green ginger cut into slices or fancy shapes.
3 to 4 teaspoonful salt
4 green chillies
¾ oz. red chilli powder
A small grain of asafoetida (optional)
1 oz. aniseeds
1 tsp. nigella (optional)
2 tsp. fenugreek seeds
2 tsp. turmeric powder
1 tbs. brown sugar

Method: Wash, dry, peel and slice the mangoes. Peel, wash and dry the button onions; wash and dry the gooseberries. Scrape the ginger and cut into thin slices or fancy shapes.

Sift and clean aniseeds, nigella and fenugreek seeds and dry, roast over medium heat. Pound roughly while hot.

Heat oil in a skillet and fry the asafoetida grain, when it swells, crush with the back of the spoon. Add sugar and remaining spices. Stir for two minutes, then remove from the heat. Add sliced mangoes, and prepared buttered onion, gooseberries and ginger. Mix thoroughly with a wooden spoon. Cover the pan with a kitchen cloth and leave to cool. Store in a sterilized jar.

Mango and Chilli Pickle

Ingredients: 1 pound mango slices (unpeeled)
½ pound green chillies
6 oz. mustard oil or groundnut oil
1 oz. aniseeds
1½ oz. fenugreek seeds
½ oz. nigella
2 tsp. turmeric powder
2 ozs. salt
1 tbs. red chilli powder.

Method: Wash, dry and slice the mangoes. Use a few halved and sliced pieces of kernel as well. Wash, dry and slit the green chillies. Crush roughly the aniseeds, fenugreek seeds and the nigella.

Heat oil to smoking point. Remove from the heat and add the spices, lastly adding chillies and the mango slices. Mix well with a wooden spoon. Cool and store in a sterilized jar.

Naurattan Chutney

Ingredients: 2½ ozs. raisins
3 ozs. dried dates or chawaras (optional)
2 ozs. blanched and halved almonds
1 oz. pistachio nuts (optional)
¼ pt. vinegar
1 pound grated mangoes
1 pound sugar
3 tsp. salt
2 tsp. salt
2 tsp. nigella (optional)
1 to 2 tsp. red chilli powder
1 tsp. black cumin seeds
1 tsp. ground cinnamon
¼ tsp. ground (dry) ginger
a few cardamom seeds (optional).

Method: Wash, peel and shred mangoes through a fine shredder. Cook the shredded mangoes with salt in a stainless steel pan over medium heat for about five to seven minutes. Stir to prevent the shreds from sticking to the bottom of the pan. Mix sugar, vinegar, cumin seeds, ground cloves, cinnamon, chilli powder, ginger and nutmeg. Crush nigella and cardaman seeds (if using) and add to the cooking mango shreds. Cook over moderate heat till it resembles thick puree.

Add almonds, pistachio, chopped dates and raisins (washed and dried previously). Simmer gently for another five minutes. Cool and preserve in sterilized jar.

Mango Squash

Ingredients: 1¼ pound sugar
1 pound mango pulp
¾ pt. water
½ oz. citric acid – yellow colouring
3 to 4 small granules of potassium metabisulphate (do not use in excess).

Method: Boil water, sugar and citric acid till sugar is dissolved. Cover with a clean kitchen towel and cool.

Mix mango pulp in the syrup and strain through a muslin cloth. Dissolve potassium metabisulphate in a tablespoonful of cooled mango juice and a little yellow colouring. Add to the juice, stir well. Pour into sterilized bottles and cork with sterilized tops and seal with paraffin wax. Store in a cool, dry place.

Mango Purée (Suitable for pie filling)

Ingredients: 6 to 8 mangoes
3 cloves
4 ozs. sugar
1 or small granules potassium metabisulphite.

Method: Heat water in a pan and boil whole mangoes till soft to touch. Drain off water and squeeze the pulp. Cook the mango pulp and the sugar with cloves over medium heat till it becomes thick puree. Cool. Mix potassium metabisulphate in a spoon with the puree and add to the rest of it. Mix well. Store in a sterilized jar.

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Discussion

Prof. Purseglove: In most textbooks we read that the pollen used for fertilization has an effect on the date pericarp, as well as on the endosperm. I would be grateful for Dr. El Baradi's views on this.

Dr. El Baradi: I know of nothing which has been done on this subject.

Mr. Alles: Apart from the export of melons from Cyprus as fresh fruit, is this fruit utilised in a preserved form, on a commercial scale?

Mrs. Sateriadou: No, preserved melons are not exported.

Dr. Hulme: Do you use ethylene for ripening honeydew melons? In California melons are ripened with ethylene at 68°F in railway trucks for 24 hours and then cooled in the trucks for transportation. It is said there that melons must be ripened early after packing and can then be transported and kept for some time in good condition.

Mrs. Soteriadou: No, we do not use ethylene for ripening honeydew melons. They turn yellow immediately on outturn. This is a variety that has good keeping quality and can stand storing for as long as a week.

Dr. Hulme: But does it ripen during shipment; so many of the melons we get in this country do not, and they are not as ripe as those from California.

Mrs. Soteriadou: Honeydew melons are exported from Cyprus during June, July and August. By that time most of these varieties are properly ripened.

Mr. E. G. Hall: I also believe that most melons need ethylene treatment to ensure uniform ripening to best eating quality. In Australia, to get uniform ripening of honeydews, 2 - 3 days treatment is essential, without it individual melons took from 5 to 50 days to ripen at 20°C. Other smooth muskmelons have behaved similarly. In this country many melons, and indeed most imported fruit is eaten before it is fully ripe. This is often a necessity as full ripening commonly requires some form of 'conditioning' at ripening temperatures and also ethylene treatment, but neither is given. The trade tends to be more concerned with market life than with eating quality, even bananas are encouraged to develop a good skin colour well ahead of the ripening of the pulp.

Dr. Pansiot: Firstly, I was impressed by the figures given for yields of muskmelon in Cyprus (30 to 35 tons per hectare) and would like to know if these figures refer to average yields.

Secondly, I would like to comment on production of seedless water-melon varieties: apart from California, there is also production of such varieties in Chile and particularly in Japan; we have imported Japanese seeds for experiments in the near East Region. The results were satisfactory but the cost of the seeds is rather high.

Mrs. Soteriadou: This is an average production.

Prof. Purseglove: At the Conference on Mango and Mango Culture which I attended recently, the following points were raised which may be of interest.

Self-incompatability has been found in a number of common cultivars. Male nuclei are delivered into the embryo sac in the normal way and fuse with the polar and zygote nuclei and no further development then takes place.

Some new good hybrids have recently been raised in India by crossing the northern cultivars such as 'Dashori', which are not regular bearing, with southern cultivars, such as 'Neelum', which are. Regular bearing clones have been produced which are precocious, fruiting at 3 years.

Polyembryonic cultivars on the Kenya coast and in the Philippines come true from seed and some of these are very good. Mango flakes are now produced in India which make a good breakfast 'cereal'.

Dr. Maliphant: In Trinidad, Mango Long and Mango Rose are used. Are these similar to those mentioned? There is confusion in terminology. The effect of rootstock on colour of fruit is of some concern in Trinidad – preferences being given to Mango Rose. I would welcome comments on this. I am rather concerned over the intense spray programme for black spot: has Mr. Hobson any experience with Benlate and the copper fungicide Kocide 101?

Mr. Hobson: The use of Benlate is still experimental. We are hesitant of using it on a large scale until tested. The Israelis have done much work on rootstocks: South African Sabre mango gives a slightly better yield than others, but generally mangoes are not fussy as regards rootstocks. Sabre is used because it transplants easily.

Dr. Gazit: Several experiments with different rootstocks have been, or are being conducted. Sabre is a good stock, and some others are not so good. In calciferous soils, Sabre is poor and research is being done to find a better rootstock.

Dr. Randhawa: Regarding rootstocks, we are trying a number of polyembryonic varieties like Olour, Pahutan, etc. in India. Preliminary studies indicate that these rootstocks are dwarfing and these may result in early and regular bearing in the scions, but work is still going on. In Alphonso mango in Western and South India we have noticed malformation in fruits when near maturity. It may be due to bacterial attack or due to deficiency of boron or calcium.

Dr. Ruck: Was the iron content much reduced in chlorotic mango leaves? Can the tree be sprayed with chelate to prevent this happening?

Dr. Gazit: We have analysed for iron content and found no difference between the chlorotic and non-chlorotic leaves. This is not unusual with lime induced variation. The main problem is not deficiency, but unavailability of iron. Iron is present in the leaf, but is probably concentrated in the veins and does not pass into the leaf blade. Spraying is not effective, partly because the chelate is very sensitive to light, and partly because penetration is poor.

Mrs. Soteriadou: Were Mr. Hobson's trials with sea shipment of mangoes to the UK successful and was there any problem of determining the green mature stage?

Mr. Hobson: The trials were successful economically, in that the mangoes were sold, but not technically, because green mangoes should be carried at about 55°F, whereas when shipped with pineapples the temperature is 47.5°F. Ideally green mangoes would be shipped initially at 60°F and the temperatures reduced to 45°F as the fruit ripened. Only Florida mangoes are suited to shipping green. In the green mature state the flesh is just beginning to turn yellow around the stone.

Mr. Alles: What is the significance of the failure of the mango harvest in alternate years?

Also, have any developments been made on methods of peeling and cutting mango mechanically?

Dr. Puri: The whole of northern India suffers from this problem. It is often found that half the tree bears fruit in one year and half the alternate year, due to the formation of new leaves.

Peeling and cutting mango is done on a small cottage scale in India, using hand instruments.

M. Mafura: La methode de greffarge par approche des manguiers est-elle employée dans une plantation intensive où dans une plantation d'essais? Dans l'un des cas quel est l'ecartement entre les plantes?

Mr. Hobson: The method of grafting used commercially in South Africa is tip grafting with a splice. The distance between the plants in the nursery is approximately 30 cm apart, they are in plastic containers which are 40 × 22 cm wide.

Dr. Yankey: Is it acceptable practice not to wash mangoes?

Mr. Hobson: In South Africa, yes. Washing is only done during the rainy season to remove mud which has splashed onto the mangoes.

Eighth Session

Thursday 18th September
Afternoon

Chairman
Professor J. W. Purseglove
Formerly Professor of Botany,
University of the West Indies

Investigations on avocado in Trinidad

E. A. Tai

Department of Crop Science,
The University of the West Indies, Trinidad

Summary

It is acknowledged that the possibility of developing commercial production of avocado on a sizeable scale in Trinidad depends very largely on (a) the behaviour in storage and transport, and on (b) extension of the season of availability of locally grown fruit: there has been limited research on both of these topics.

Experiments conducted by Wardlaw and Leonard in (1935) with fruit of the West Indian race of avocados have shown that storage at temperatures below 53°F. induces chilling, resulting in unsatisfactory ripening and poor flavour while the maximum useful storage life at higher temperatures is normally less than 14 days; few selections have proved capable of withstanding storage at 45°F. for two weeks or longer without symptoms of chilling and these ripen and deteriorate rapidly when kept subsequently at atmospheric temperature. These results were confirmed by Halkon in 1968.

It is known that fruit of the Guatemalan and Mexican races and hybrids of the West Indian with these can satisfactorily withstand storage at 40 - 45°F. and that the season of maturity varies widely between individuals. The growing of hybrid avocados, coupled with judicious selection among West Indian 'cultivars' in Trinidad might, therefore, be a means of arriving at an extended season as well as the provision of fruit suitable for storing at temperatures which could make possible economic transport overseas for development of an export trade.

A programme of introducing a large number of hybrids was commenced late 1967; scion material of named cultivars of commercial importance elsewhere and seed from desirable-seeming parent trees are being used. Propagation experiments were initiated early to evolve suitable techniques for effective multiplication of each introduction. It has proved practicable to employ shield-budding or wedge-grafting of softwood scions on very young avocado seedlings in the greenhouse to produce plants ready for the field in six months from seed; seedlings of a Guatemalan x West Indian hybrid, Lula, have given better results than West Indian seedlings. Observations made on approach-grafting young seedlings from introduced hybrid seed to bearing trees have indicated that it may be possible thereby to reduce the period of juvenile growth.

Avocado is a favoured article of diet in Trinidad, as it is throughout the West Indies; it is consumed in the form of fresh fruit alone or as an ingredient of salad or other dishes throughout the season of its availability. This season normally extends from July to October when the fruit occurs in relative abundance throughout the country. The source of supply is, in the main, a large number of scattered seedling trees growing among crop plants on cocoa estates and in back-gardens; there have been few attempts at intensive orcharding. The overall domestic demand is seldom, if ever, exceeded by the supply although problems of distribution at times result in the occurrence of local gluts.

Plants of the West Indian race preponderate in the population of trees grown in Trinidad; they cover a wide range of variability in all characters – size, colour, pulp quality, oil content etc. – and it is natural that this lack of uniformity should militate against the development of an export trade or establishment of the standards on which such a trade might be based. Efforts to introduce named cultivars of the Guatemalan and Mexican races from areas in which these were grown on a commercial scale met with limited success in the past, most likely because of failure to set sights on a clearly defined objective as regards the type of avocado production sought. Wardlaw (1938) stated 'Whether avocado cultivation is considered in terms of an export industry or from the stand-point of improving local supplies, the basic factor requiring attention is the same, namely, the selection of types possessing (i) good horticultural qualities in respect of productiveness, resistance to disease etc. (ii) desirable commercial qualities including palatability, oil content, size, appearance, ratio of stone to pulp etc., (iii) an extended cropping period, and (iv) good keeping quality in cold storage, yet Lucie-Smith (1950) lists among the introductions grown in Trinidad such widely different avocados as Pollock and Simmonds (West Indian); Panchoy (Guatemalan), Winslowson, Collinson and Lula (Guatemalan x West Indian hybrids); Fuerte (Guatemalan x Mexican hybrid) and Mexicola (Mexican); on the last-named he makes the comment 'Why it was ever introduced to Trinidad is hard to imagine'.

It is reasonable to accept that two prime requisites for a successful avocado trade are a guaranteed supply over as long as possible a period each year and an efficient

method of distribution to ensure arrival of fruit in a satisfactory condition at the selected marketing points. The matter of fruit quality, with all that the term entails, is also of very great importance and must be given attention in any programme of investigation aimed at effective economic production and marketing of avocado. In Trinidad attempts have been made to devise workable storage and transport procedures for avocado fruit already available from established production and also to investigate the production of other avocados introduced because of their potential suitability for commercial purposes under local conditions.

Storage Trials

To secure information that might be useful in developing an avocado export trade with North America and, possibly, Britain, storage trials were initiated at the Imperial College of Tropical Agriculture Low Temperature Station in 1933. The material used consisted of the highly variable fruit from the named cultivar, Pollock, and 32 different seedlings of the West Indian race. It was found (Wardlaw, 1934) that the behaviour of these was widely different from avocados used in storage experiments in California; chilling injury occurred in nearly all fruits kept at a temperature between 40°F and 45°F for 30 days. In a number of instances the effects of chilling were observed after 15 days at 53°F; in others the characteristic chilling effect developed in 15 to 20 days at 40 - 45°F and some fruit including Pollock, stored satisfactorily in the same temperature range up to that time, but were chilled when kept for a further 10 days. The fruit from three trees, however, remained in good condition throughout and ripened normally in 4 to 7 days when transferred to a temperature of 70°F.

For the trials the avocados were picked when they were full-grown but still firm; at this stage they softened in 5 to 8 days at tropical room temperature (80°F). When kept at lower temperatures they required longer to soften but it was evident that the ripening process was not halted, it was only slowed, between 80°F and 40°F; even chilled fruits eventually softened. For fruit from one source the time taken to ripen was 5 days at 80°F, 6 to 8 days at 70°F, 15 to 17 days at 53°F, 30 days at 45°F; when transferred to a temperature of 70°F after 20 days at 45°F softening occurred 4 to 6 days later.

It was observed that there was a considerable lag between fruit pulp temperature and that of circulating cold air; even after 10 days of cooling the internal temperature of fruit was appreciably higher than that of the storage room. Concentrations of carbon dioxide up to 15% of the surrounding atmosphere caused no apparent injury to stored fruit; there were indications that storage life may be prolonged suggesting possible advantages of controlled atmosphere storage. When the concentration of carbon dioxide reached 20%, however, there was superficial scalding and internal deterioration.

In 1934 experiments were carried out (Warlaw and Leonard, 1935) with 'gas-storage' of avocado fruits at a temperature of 60°F using (1) restricted ventilation, (2) sub-normal concentrations of oxygen in nitrogen and (3) mixtures of oxygen, carbon dioxide and nitrogen. Wide variation was observed in the response shown by fruit from different trees to the treatments applied though, generally, low oxygen alone or in conjunction with high carbon dioxide resulted in delayed ripening. In a number of instances susceptibility of fruit to storage rots increased with rising carbon dioxide concentration; this was quite distinct from physiological injury in fruit apparently unsuited to gas-storage.

Wardlaw and Leonard (1935) also used different wraps and coatings of fruit to delay ripening as a result of the restriction on gas exchange. They found that coats of vaseline, beeswax and similar substances maintained fruit in an unripe condition beyond the time normally taken to soften but resulted in non-parasitic skin blemishes of the type associated with low oxygen and also failure to ripen properly.

The results were confirmed in experiments (Halkon, 1968) with fruit harvested from West Indian seedling trees in Grenada and brought to Trinidad for cool storage treatments; some of the ffuits were precooled in Grenada at 45°F - 50°F for varying lengths of time before being shipped on the deck of a schooner. There was absence of uniformity in the behaviour of fruits at all storage temperatures between 40 - 55°F but chilling injury usually occurred after 7 days. Wrapping in sealed polyethylene bags was observed to prolong storage life more than other wrapping treatments at any temperature; in one trial the polyethylene-wrapped avocados required an average of 20 to 21 days to soften compared with 12 days for un-wrapped fruit.

Most of the avocado fruit obtainable in Trinidad at present cannot be regarded as sufficiently cold-resistant for commercial purposes, taking storage at 45°F for 15 to 30 days as a safe criterion, although there may be individual trees which bear fruit capable of meeting the requirements. It is necessary to isolate these for critical testing with a view to final selection and multiplication.

Introductions

The difficulty of finding a suitable 'local' avocado has suggested introductions of others known to possess the required attributes. In this connexion suitability for cold storage is not the only important desideratum and consideration has been given also to extending the season of availability of fruit. Past attempts (Lucie-Smith, 1950) have been without notable success; cultivars from Florida and California have behaved in Trinidad quite differently from the way they do in their areas of origin.

Mexican avocados are more cold-resistant than others but show few additional desirable characteristics; the trees are intolerant of tropical conditions and unlikely to perform satisfactorily in Trinidad; Mexicola and Gottfried did not survive for long. Nearly all of the Guatemalans and many Guatemalan x West Indian hybrids produce fruit which is cold-tolerant and therefore potentially acceptable for commercial production. They also take

longer to mature than West Indian avocados – 7 to 13 months compared with 5 months – and it is within those two groups that the best hopes of a Trinidad avocado export trade must lie. It is possible that early disappointments with several of the cultivars already introduced may be overcome with the development of suitable horticultural procedures but more likely that selection from the new material now available may satisfy requirements.

Current Work

In 1967 a project was initiated at the University of the West Indies with the aim of establishing a foundation for commercial avocado production. This involved a wide-ranging selection, from whatever avocados could be collected, for the following characters which are regarded as most desirable:

- i medium-sized to large fruit weighing 12 - 24 ozs. at maturity, preferably ovoid in shape with a smooth exterior remaining green when ripe;
- ii leathery skin of medium thickness;
- iii relatively thick flesh of firm, buttery consistency, nutty flavour;
- iv small seed making up a maximum of 20% of the weight of the fruit at maturity, filling the cavity completely but easily separated from the flesh;
- v ability of fruit to withstand storage at 45°F for 15 days and ripen normally after;
- vi extended season of harvesting (a complex of several clones will be required for this).

Selection based on other characters – vigour and habit of tree, bearing pattern, yields, resistance to disease etc. – will be done on avocados satisfying the initial criteria.

The work can, for convenience, be regarded as falling under three heads – collection, multiplication and testing.

Collection: Many named cultivars which are commercially important in recognized avocado producing areas have been brought into Trinidad as scion material in small quantities for nursery propagation as a prelude to testing later; these have come from Hawaii, Florida, California, Costa Rica and Puerto Rico. Scions of unnamed avocados likely to prove of value have also been added to the collection; some tentatively selected in Trinidad by Wardlaw and Leonard over 30 years ago are included as well as others, adjudged superior in different ways to the general West Indian avocado population, from Grenada and Jamaica. It was, fortunately, possible to benefit from the programme conducted at the University of California. Scions from seedlings kept under observation for varying lengths of time (Storey and Bergh 1963; Bergh and Storey 1964) and seed from trees known to yield progeny with highly desirable characters have been made available. By mid 1969 there were 75 clones and nearly three times as many seedlings in the collection for testing.

In preliminary screening, two criteria are given priority: season of harvest and ability to withstand cold storage. The tests applied are simple: fruit must be observed to mature out of season, between November and the following July, and also survive without chilling storage for 15 days at 45 - 55°F.

Multiplication: In realization of the need for efficient procedures for propagation, attention has been given to avocado nursery practices. One recommended by Tai and Boland (1953) is based on shield-budding of vigorous young seedlings in pots in the greenhouse; it was found possible to effect an improvement by use of wedge-grafts on rootstock plants of a very tender age, before any leaves with developed laminae are produced. Maximum success was obtained when scions were prepared from actively growing terminal shoots.

To produce rootstock, seeds of West Indian avocados are collected at random and grown in polyethylene bags. Normally, germination of intact seeds requires 30 to 40 days and the seedlings can be worked about a fortnight later; a plant suitable for setting in the field results in 120 to 200 days from grafting. Such a variability is considered undesirable and studies of possible means of circumventing it are in progress.

Removal of the seed-coat before sowing was found to reduce the time required for germination of seed by 25 - 50% and although no significant difference in subsequent growth of seedlings was observed, a saving of 15 - 20 days between sowing and budding could be effected. Typical figures are:–

Sowing	*Treatment*	*Germinated*
12.8.68	intact	30.8.68 - 18 days
	minus testa	20.9.68 - 39 "
29.8.68	intact	14.9.68 - 16 days
	minus testa	20.9.68 - 22 "

Use of steam-sterilized media for growing the avocado seed gave greatly increased survival rate of seedlings. The standard procedure now consists of

(1) washing all seed in a dilute solution of sodium hypochlorite;

(2) removal of seed-coats, or as much as possible without undue expenditure of time;

(3) sowing in sterilized cocopeat (waste from coconut husks after extraction of fibre) in flats with the tip of each seed barely covered;

(4) removal of each seed as soon as the young seedling shoot projects beyond the cotyledons to a polythene bag filled with soil-compost mixture.

Uniformity in the times of germination, attainment of grafting size and production of final nursery plant should, theoretically, be achievable by using seed from single trees or clones for propagation; tests made so far tend to support the view but the variation between individual seedlings or clones is wide. Several named cultivars and identifiable un-named seedling trees have been tried as sources of seed for rootstock plants and the screening is being continued. The best performance has, to date, been given by Lula, a large-seeded Guatemalan x West

Indian hybrid which matures its fruit between September and February in Trinidad. The seedlings are vigorous and grow to a height of 22 - 25 cm before the first leaves are expanded, thus presenting a clean, smooth stem for easy working, and the timing is almost perfect for Trinidad conditions where growing operations are best confined to the greenhouse between December and April, when the intense dry season restricts growth in the field. Figures for comparison between Lula and West Indian seedlings are given in the following table

	Sown	*Potted*	*Grafted*	*Final Plant Ready*
Lula	26.9.68	39 days	84 days	201 days
	16.10.68	23 ,,	64 ,,	181 ,,
W.I. seedling	12.8.68	33 ,,	109 ,,	256 ,,
	27.8.68	23 ,,	94 ,,	241 ,,

Limitations are placed on the interpretation of these by the unavoidable latitude allowed to suit other activities in the greenhouse.

Testing: Observation plots have been established in seven different locations and records are being kept of the behaviour of each avocado clone. The first planting was done in early 1968 and additions are made whenever new selections are propagated. The information obtained from these observation plots must be treated as preliminary because of absence of knowledge of the effects of rootstock variability. Arrangements are in progress to make more valid comparisons under better controlled conditions of those clones which show promise in the initial screening.

The majority of the named cultivars in the observation plots are Guatemalan x West Indian hybrids; there are also some pure West Indian, some Guatemalan x Mexican crosses and others believed to be the result of a mixture of all three races. There has yet been no clear indication of superior vigour of the West Indian avocados compared with the others; all have shown better growth on the well-drained loams on sloping land than on the flat although planted in mounds located on cambered beds.

Avocado trees grown from vegetatively propagated nursery plants normally flower three years after being set out; seedlings require 5 to 7 years. In an endeavour to shorten the waiting period and so speed up the testing process, topworking of bearing trees is being tried. Shield-budding, wedge-grafting and splice-grafting of young shoots have all resulted in a high percentage of 'takes' but in many instances rejection has occurred. Plans have been formulated for investigation of this phenomenon.

An approach-grafting procedure with seedlings grown from seeds introduced from California shows promise. A reverse of standard 'inarching' is employed in that the upper portion of the seedling is transferred to a selected shoot on the full-grown avocado tree and eventually made to replace the old top. Union is usually firm in 3 to 4 weeks and the shoot allowed to grow unsupported but protected from wind. The juvenile character of the seedling shoot is modified by the procedure; its rate of growth is accelerated in comparison with seedlings of comparable age, and production of branches with shorter internodes similar to those on older trees takes place. If the change of habit is accompanied by earlier fruiting this topworking method will prove of value to avocado breeders.

The use of rooted cuttings from the California seedlings has not proved successful in inducing early fruiting. The cuttings rooted in 10 to 12 weeks and were large enough to be transferred to the field 5 to 6 weeks later, but continued to grow with typical seedling habit in the juvenile phase of development.

Some attention is being given to a study of the avocado root disease which is universally a serious problem. In a 'rhizotron' recently constructed at the Field Station of the University of the West Indies the growth of both healthy and diseased roots is under close observation. Seedlings of the cultivar 'Duke' which is believed to show resistance to the fungus *Phytophthora cinnamomi* Rands. under certain conditions, and the species *Persea donnell-smithi* Mez. are being compared with standard nursery produced trees on different West Indian avocado rootstocks.

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Fruits of South-East Asia

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Appendix by G.E. Howard

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Summary

The biology of the fruits of equatorial South-East Asia has received little study. Their acceptability to western palates is variable, but nevertheless they are important items of diet and trade to peoples of the Indo-Malayan and Pacific cultures. There has been a limited reciprocal transfer of cultigens with the homoclimatic Caribbean and Latin American Regions and they are of potential value as trade crops in these areas, also.

The problems of commercialization arise from the seasonality of the crops and the lack of selection and plantation development. They also present problems in the control of ripening. Existing techniques of horticulture, breeding and selection, and post-harvest treatment could be applied to improving the economic exploitation of these fruits in both regions.

One of the most prized fruits of the area is the durian (*Durio zibethinus* Murray), which is cited as an example.

International trade in fruits is remarkably conservative and seems to have been based on European and Mediterranean preferences. This is reflected in the small amount of research which has been conducted on tropical and subtropical fruit crops. The banana is the exception to the rule that 'the international fruit trade has been confined to temperate zone or evergreen subtropical species'. On cultural and historical grounds the banana can be grouped with the evergreen and subtropical fruits, though ecologically it is part of the group of fruits which is the subject of this paper.

Other Cultures

The apparent monopoly of apples, pears, oranges and other citrus fruits in world trade ignores the trade relationships which have existed for a thousand years between the various regions of Southeast Asia, the cultural situation which has been likened to that of the Mediterranean by eminent geographers such as Fisher (1964) with the South China Sea taking the place of the Mediterranean as the focus for the cultural and commercial exchanges.

Another feature of this natural region which is populated by Sino-Malay and Polynesian peoples is the strongly developed food patterns and preferences which are distinctive though they have absorbed elements of the large cultural groups to the North and West.

This region also differs from those previously mentioned and is unique in being a highly developed lowland fluvial culture which straddles the Equator. Equatorial food systems, as distinct from those of the tropical and temperate zones, are characterized by a relatively regular food supply throughout the year, in contrast to the more temperate zonal systems with a strongly developed seed-time and harvest, storage system and 'hungry' season.

We may add to these axioms the fact that no highly industrialized urban situation was developed in this equatorial culture, and hence no urban pattern of demand, marketing, transport and cash trading system which such urban industrialization generates. That is, hitherto, each city state subsisted on its own hinterland.

All this is now changing, and urban industrialized markets are developing on the equator based on populations with food habits very different from those associated with the normal trade fruits.

Unfortunately it is not possible to convert, overnight, fruit species which are part of a gathered, or short-term storage, economy into those which can be absorbed into international trading and processing systems.

Westernization

Also, the imported industrial technologies have brought along with them tendencies to change food habits, and we find that the urban communities of Singapore, Djakarta, Manila, and Kuala Lumpur demand apples, grapes, oranges and other fruit imports from USA, Australia and Europe. Alongside this, there is still recognisable the strongly developed cultural affection for a group of indigenous Indo-Malay tropical fruit species and such pan-tropical species as the pineapple and the mango.

Diversity of Species

It is a characteristic of the equatorial flora (Van Steenis, 1962) that there is a great diversity, even at the highest taxonomic level, in the main lowland ecological groupings, in contrast to that found in temperate zone ecological systems. This is reflected in the diversity of tree species in the equatorial forests, creating a problem for the forester, and this diversity is also true of equatorial fruit species. Whereas a survey of the temperate zone fruits can be effectively covered by reference to the family *Rosaceae* and the genus *Citrus,* the four species which I shall be discussing, namely the Durian *Durio* sp., the Rambutan *Nephelium* sp., the Mangosteen *Garcinia* sp., and the Langsat *Lansium* sp. all belong to different orders. This dispersion among the higher taxa also applies to the pineapple, the banana, the mango, and others. The taxonomic position is shown in Table 1. This selection is a small fraction of some of the 40-odd species recognized by economic botanists as typical garden (*dusun*) fruits of the region (Terra, 1954). These species are among those most frequently encountered in the markets of southeast Asia, and have been selected because some work has been done on them in contrast to the many others on which research is completely lacking. The limited research provides clues on the incorporation of these little known fruits into Regional or World trade patterns of the future.

Table 1
Taxonomic position of the fruits discussed in this paper

Taxa	Polypetalae				Note 4
Order	Malvales	Sapindales	Guttiferales	Meliales	Anacardiales
Family	Malvaceae (Bombacaceae) (1)386 (2)871 (3)(I)261	Sapindaceae (1)769 (2)1543 (3)(I)498	Guttiferae (1)466 (2)1046 (3)(I)167	Meliaceae (1)617 (2)1314 (3)(I)410	Anacardiaceae (1)692 (2)1400 (3)(I)520
Genus	*Durio*	*Nephelium*	*Garcinia*	*Lansium*	*Mangifera*
	D. zibethinus	*N. lappaceum*	*G. mangostana*	*L. domesticum*	*M. indica*
Name Common	DURIAN	RAMBUTAN	MANGOSTEEN	LANGSAT	MANGO
'Malay'	Durian	Rambutan	Manggis	Langsat	Mangga

Note *acc. to*
(1) Willis, J. C. (1966) *A dictionary of the flowering plants.* 7th ed. C.U.P., Cambridge.
(2) Burkill, I. H. (1935) *A dictionary of the Economic Products of the Malay Peninsula.* Crown agents for the colonies, London.
(3) Ridley, H. N. (1922) *The flora of the Malay Peninsula.* L. Reeve, Covent Garden, London
(4) This table could be extended at the order level in contrast to the limited diversity of temperature fruits.

Acceptability

We must not assume that other regional groups of potential consumers have, or are likely to acquire, the same fruit preferences as the European. For instance, the West African prefers a low acid orange in comparison with that accepted by Europeans, and the peoples of Southern Chinese and Malayan origin have textural and taste preferences, which even after close experience are difficult to appreciate completely. Malay peoples seem to like very sweet foods, lacking the ester, tannin and organic acids flavours to which the European is accustomed. Food preference is an undeveloped subject and requires further research in the tropics (see for instance Read in Yudkin and Mackenzie 1964). The Southern Chinese do not rate sweet foods highly yet share with the Malays a preference for extremely strong putrid flavours, which to European palates would be considered objectionable, in their savoury foodstuffs. This preference for strong indole-type and sulphurous aromas is reflected in the very high esteem with which the first of the fruits listed in Table 1 is held, namely the durian. By contrast, the other three fruits listed show a fairly simple sharp, sweetish taste and delicate aroma, but to the European one that is not memorable. People not of southeast Asian origin on first encountering the durian are normally repelled. The other three fruits are characteristic of a large group of tropical fruits which to the European are refreshing, but in the long term, would probably not be changed for the accustomed species. This is partly the reason why they have never acquired a strong position in temperate zone trade. However, if they are regarded as having potential value for inter-regional trade, or trade to other tropical areas of the world where there might be similar food preferences, then there is justification for the further study of these tropical species.

The Nature of Domesticated Species

It must not be forgotten that over the last 200 years there has been a great loss of diversity of the garden fruits of Europe. One has only to look at the great 'pomonas' of the late 18th century to realize that all but about 0.2 per cent of the pear varieties common in northern Europe have never entered the trade, or been lost to cultivation completely, and a similar figure may be set against apple varieties. This diversity is not yet lost to the fruit species of Southeast Asia (Terra, 1954) and it is available for selection of the 'trade species' of tomorrow. A start has been made on this process, as reported by agronomists and botanists in Indo-china, the Philippines, Indonesia and Malaysia, but unfortunately the Second World War interrupted this long-term research. Many of the records were lost and many of the experimental plantations destroyed. Since the War, priority in research has had to be given to other aspects of economic reconstruction, so that from a research point of view the fruit specialist is commencing, with some exceptions, from a position which was obtained somewhere about 1935.

For the durian there are extensive descriptive records on the gathered species (Soegang-Reksodihardjo, 1963). Also, early-bearing and heavy yielding high quality clones have been selected which are finding their way into commercial cultivation. Similar work has been done on the rambutan (Milsum, 1960). However, from the point of view of trade and processing, length of season and transportability are important and it is in these fields of study that research is still required, although some early and late selections of the species I have mentioned have been made. Climatic factors affecting production of an equatorial crop are unlike those of other latitudes such as day-length, rainfall and temperature, and create special problems in plantation agronomy.

Seasonality of the Equatorial Climate

The geographical region, Southeast Asia, straddles the equator and is shown in Figure 1.

Equatorial rainfalls are described by the climatologists as regular; typically, a locality such as Singapore has a rainfall of 2,500 mm of which 200 mm can be expected in almost any month (Dale, 1960). Similarly, the annual climatic range is narrow and the daily mean temperature level and range are similar throughout the year. Nevertheless some of the species, which have been studied, show a marked seasonality under these equatorial conditions. This presents problems from an economic point of view. One of the species most intensively studied, due to the commercial interest in the crop, is the oil palm. Seasonal variability is illustrated in Figure 2. (Hartley, 1967). Further instances may be cited in the so-called wintering of the rubber tree. This occurs as a seasonal leaf-shedding, which affects latex flow. This uncertainty of the equatorial climate and its effects on plants is discussed by Corner (1940) and by Holttum (1954).

The sample of fruit species also share marked seasonality. Unfortunately it is difficult to keep accurate records of yield, except where the orchards are closely guarded, and this has limited the value of records from the point of view of estimating yield, seasons of bearing and the selection of individual trees.

In spite of these difficulties, Whitehead (1959) and Dickinson (1959) summarizing work in Malaya on selection of rambutan started in 1932 have assembled much useful data on the crop from observations made at some thirty sites in the peninsula.

The variation in season of fruiting is illustrated in Figure 3.

If it is accepted that there are local markets, which are large enough to be recognized for intra-regional trade purposes, and for the development of an infra-structure of storage, transport and processing facilities, the next consideration in the marketing situation is the question of regularity of supply and quality control.

The durian in particular is a highly prized fruit, for which a high price is paid. It is said there is addiction to this fruit: elephants are reported to be hallucinated,

and also the orang-utang, after gorging themselves on durian. The local people also report medicinal properties of the seeds, which are sometimes roasted and eaten. Analyses conducted on the seeds and trials on rats, have shown a growth-depressing effect, but no potentially hallucinogenic compounds. The search was made specifically for the indoleamines which might, *a priori*, be considered to be present on the basis of the smell of the fruit. However the thresholds for this particular group of compounds are extremely low, beyond the limit of detection by gas chromatography. Subsequently, the aroma fractions of the durian fruit have been studied. This work is in progress at the present time, and we have found, as was predicted in an earlier paper (Stanton, 1966) that these fruits are extremely rich in sulphur compounds. They also have an ester component, which we are in the process of characterizing (Howard, Baldry and Stanton, unpublished).

In future, selection of durians for quality may possibly be avoided on an *ad hoc,* or taste, basis. *Ad hoc* selection is known to be unreliable with some of these groups of compounds, since they rapidly produce taste shadows, or olfactory anaesthesia, when present in large amounts; the question remains open as to whether they have any other pharmacological properties, or what physiological, ecological or reproductive role they perform. At present, one of the more unusual products from the durian is an ice-cream which, if the flavour can be characterized sufficiently closely, might be simulated by a synthetic durian flavouring compound. Various conserves are also made with the durian which might be simulated. This development would be unfortunate, but it seems inevitable. The botanists' and plant breeders' efforts will then, as has happened with many other special crops of the past, be undermined unless legislation occurs to protect the 'fruit content' of these preparations.

Table 2
Common Garden Fruits of Lowland Java

Genus	Species	Java 'malay' name (Note 1)	Taxonomy: Family	Taxonomy: Order
Artocarpus	champeden integra rigida	chempedak nangka temponek	Moraceae	Urticales
Antidesmas	bunius	buni	Euphorbiaceae	Euphorbiales
Anona	muricata reticulata	nangka londa kanowa	Anonaceae	Anonales
Achras	sapota	chiku	Sapotaceae	Ebenales
Anacardium	occidentale	jambu monyet	Anacardiaceae	Sapindales
Averrhoa	bilimbi carambola	balimbing balimbing alas	Averrhoaceae	Geraniales
Bouea	macrophylla	kundang	Anacardiaceae	Sapindales
Baccaurea	dulcio motleyana racemosa	ketuba rambeh –	Euphorbiaceae	Euphorbiales
Cynometra	cauliflora	nam nam	Leguminosae	Rosales
Citrus	maxima reticulata aurantifolia limos	jeruk adas – liman amkian –	Rutaceae	Rutales
(Canarium commune)		kenani	Burseraceae	Rutales
Carica	papaya	kates	Passifloraceae	Passiflorales
Chrysophyllum	cainito	caimito	Sapotaceae	Ebenales
Durio	zibethinus	durian	Bombaceae	Malvales
Diospyros	discolor	mobolo	Ebenaceae	Ebenales
Dialium	indum (ovoideum)	asem china, kuranji	Leguminosae	Rosales
Eugenia	aquea cumini jambos (jambolana) javanica malaccensis	jambu uwer (ayer) juwet, juwet manting jambu dersana (rose apple) jambu dersana jambu dersana	Myrtaceae	Myrtales

Table 2 (*continued*)
Common Garden Fruits of Lowland Java (*continued*)

Genus	Species	Java 'malay' name (Note 1)	Taxonomy Family	Order
(Feronia sp.)		(wood apple)	Rutaceae	Rutales
Flacourtia	rukam inermis indica	rukem, saradon lobi lobi baga, ru	Flacourtiaceae	Bixales
Garcinia	dulcis mangostana (cambozia)	mundu manggis	Guttiferae	Guttiferales
Lansium	domesticum	langsat	Meliaceae	Meliales
Mangifera	caesia foetida odorata (indica)	binjari manggis bawang (horse mango) kebem bem	Anarcardiaceae	Sapindales
Manilkara	kauki	sawo	Sapotaceae	Ebenales
Morus	alba	tut	Moraceae	Urticales
Nephelium	lappaceum mutabile longana (chryseum, caudifolium)	rambutan pulasan lungan	Sapindaceae	Sapindales
Phyllanthus	acidus (disticus)		Euphorbiaceae	Euphorbiales
Psidium	guajava	jambu biyawas	Myrtaceae	Myrtales
Passiflora	laurifolia quadrangularis	buah susu (passion fruit) timun belanda (grenadilla)	Passifloraceae	Passiflorales
Pithecolobium	dulce		Leguminosae	Rosales
Punica	granatum	dalima	Punicaceae	Lythrales
Persea	gratissima	adpokat	Lauraceae	Laurales
Salacia	edulis	hempedae	Celastraceae	Celastrales
Sandoricum	koetjape	sentol; buh htaal	Meliaceae	Meliales
Spondias	Cytherea (mangifera)	kedondong jawa	Anarcardiaceae	Sapindales
Tamarindus	indica	asam jawa	Leguminosae	Rosales
(Ziziphus spp.)		kuku lang (inc. jujube)	Rhamnaceae	Rhamnales

Note 1 The 'species' and 'malay' names are bracketed together as they are frequently, interchanged in different dialects and localities or the 'malay' name may refer to a number of species.

Note 2 Additional sp. of Burkill (1935) in brackets.

Appendix
Analytical note on the volatile flavouring constituents of the durian

The volatile constituents of about 400 g. of ripe durian pulp were distilled at a pressure of about 2 torr and were condensed in a series of traps, the first two of which were cooled by means of solid carbon dioxide, and a third was cooled in liquid nitrogen. The distillation was therefore carried out at low temperature. The contents of the three traps were combined to give a distillate that possessed the typical durian odour.

Small portions (about 1 ml) of the distillate were tested with various reagents. The addition of phenylmercury acetate caused no detectable change in odour which suggests that thiols do not play an important part in the odour. Mercuric chloride, however, removed the

garlic or onion note from the odour, indicating that thioethers are important. Hydroxylamine hydrochloride had no effect on the odour. Sodium hydroxide removed the fruity note very slowly, and alkaline hydroxylamine removed it very quickly. The fruity note was therefore likely to be due to the presence of esters.

Phenylmercury acetate was added to a larger portion of the distillate which was then re-distilled at about 2 torr. A portion of the residue was treated with dithizone in ethanol to liberate any thiols but no thiol odour was detected. The remainder of the residue was examined by thin layer chromatography (Howard and Baldry, 1969) but no spots were formed. This confirms that thiols make little or no contribution to the odour. Chloramine-T was added to the distillate from the phenylmercury acetate to convert thioethers into sulphinimines. A portion of the product was reduced by tin and hydrochloric acid and the garlic-like odour was regenerated. Another protion was examined by thin layer chromatography (Howard and Baldry, 1969). The chromatogram. contained three spots, the largest spot had an Rf value similar to that of diethyl thioether. The next in size (which was only about ¼ the size of the largest) had an Rf similar to that of dimethyl thioether, and the smallest had an Rf similar to that of methyl propylthioether. It must be emphasized that these identifications are only tentative. It is possible that branched chain thioethers, or unsaturated thioethers of higher molecular weight might have Rf values similar to those of the compounds mentioned.

The remainder of the original distillate was extracted with a very small amount of isopentane in a liquid/liquid extractor of the type known as a Likens head (Likens and Nickerson, 1964). The extract was concentrated further by fractional distillation which caused the loss of most of the sulphur compounds. The concentrate, however, had an odour still recognisable as that of durian, although the garlic note was much weaker. This extract was examined in a gas chromatograph fitted with a 1 to 1 stream splitter between the end of the column and the detector so that the substances emerging from the column could be smelled by the operator. The chromatogram shown was obtained from 100μ1. of extract injected on to a column 18 ft. long containing 5 per cent of polypropylene glycol on DCMS treated "Chromosorb-W". The column was temperature programmed in a stepwise manner and the points at which the temperature was increased, and the temperatures to which it was increased are marked on the chromatogram. Peak 1 was due to the solvent; Peaks 2 and 3 had a weak ester-like odour somewhat reminiscent of butter. Peak 4 had a weak ester-type odour. Peaks 5 and 6 also had a very weak odour. Peak 7 had a slightly sour note. Peaks 8 and 9 were almost odourless. Peak 10 had a very powerful fruity odour and was clearly the dominant constituent of the fruity note of the durian. Peak 11 had a rather rancid odour. Peak 12 had a faintly fruity odour, somewhat reminiscent of apples. Peak 14 had a faintly pungent odour. The last peak, No. 17, when it first began to emerge had an odour reminiscent of fresh soot. At the greatest concentration, however, it was more phenolic and napthalene-like.

One may sum up these preliminary findings by saying that the odour of the durian consists of two parts, namely the garlic, or onion-like, note which appears to be due to three thioethers, and the fruity part which seems to be due mainly to esters and one ester in particular. No doubt, if a larger sample had been taken, more peaks would have appeared on the chromatogram and it is probable that all these substances make some contribution to the odour of the durian but individually they are far less important than the substances mentioned. The next task in this work will be to identify the detected compounds by mass spectrometry.

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Figure 1

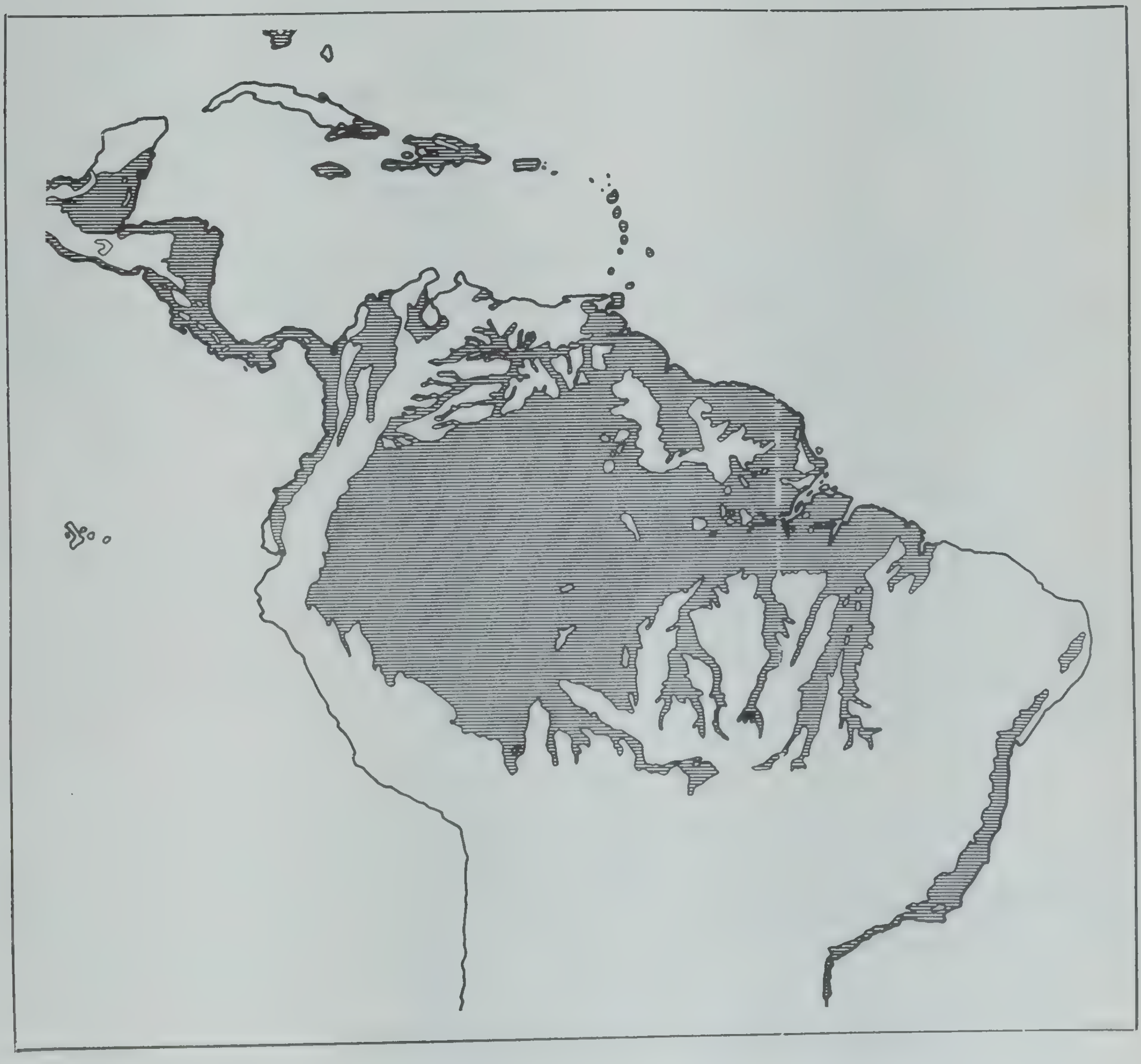
(a) South East Asia showing dipterocarp rain-forest areas, the home of the durian

(b) Areas of Central and South America homoclimatic to the shaded area in Fig.1(a)

Footnote to 1a

The original dipterocarp areas of Java and South Sumatra have been replaced by cultivated land. Nevertheless they are part of the durian endemic zone.

(a)



(b)

Figure 2

Annual variation in bunch production of the oil palm in southern Malaya

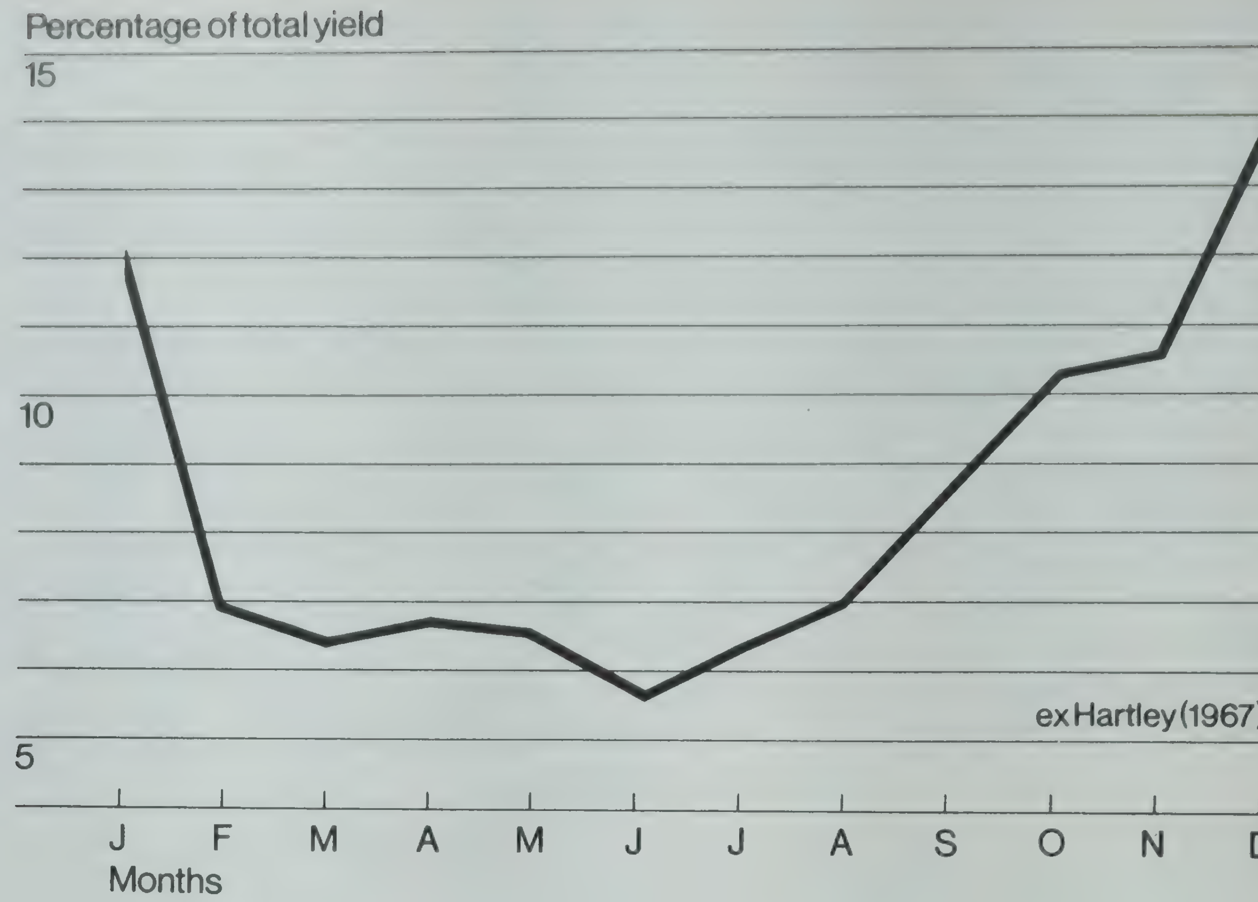


Figure 3

Harvesting dates of the rambutan throughout the year

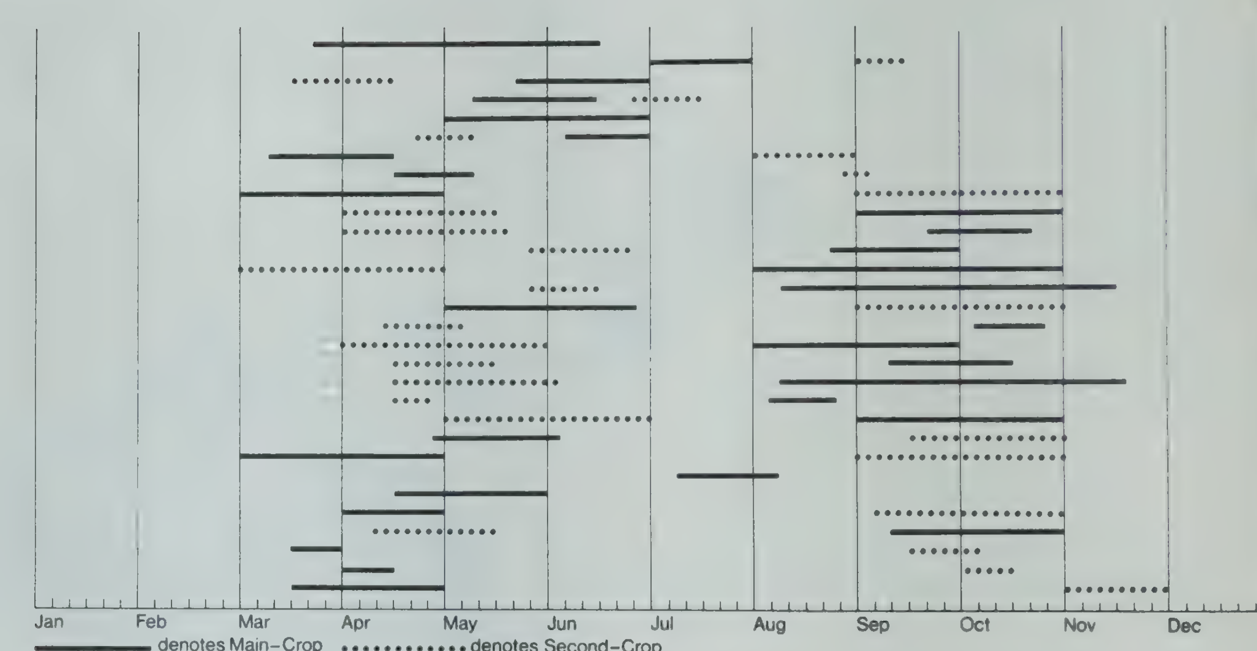
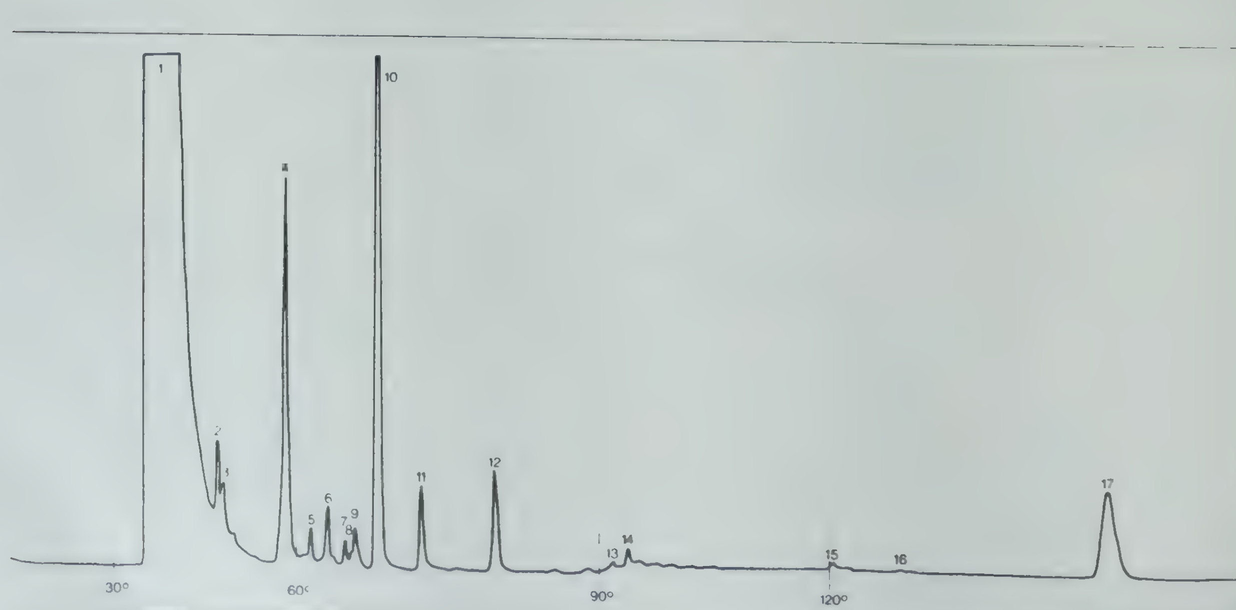


Figure 4

Chromatograph of the volatile constituents of the durian



Citrus fruit temperature in relation to sunburn

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Summary

Studies in the field showed that temperature of the albedo of the side of the fruit exposed to the sun was significantly higher than that of the exposed flavedo and the centre of the fruit. Temperature of the exposed flavedo was also significantly higher than that of the flavedo on the shaded side of the fruit. Temperatures of the different parts of the fruit on the south side of the tree was significantly higher than that of the corresponding parts of the fruit on the north side of the tree.

A survey of the fruit sunburn problem in four citrus varieties in coastal and desert orchards indicated that the sunburn was greatest in the Baladi mandarin and least in the Clementine tangerine, the Baladi sweet orange and the Sangtara mandarin being intermediate in susceptibility.

Laboratory studies on heat tolerance of citrus fruit rind grown on a nutrient agar medium confirmed the same order of heat tolerance in the four varieties.

Introduction

Citrus fruits are subject to sunburn which, under field conditions, is observed on the side of the fruit exposed to direct sunlight. The present investigation was started in 1967 to determine how far temperature was correlated with sunburn both *in vivo* and *in vitro.*

Materials and Methods

Field studies

In order to investigate the effect of direct exposure of citrus fruit to solar radiation during midday on temperature of different fruit parts (flavedo, albedo, and centre of the fruit) a series of experiments was carried out in 1967 and 1968. Trees used in this study were grown in coastal and interior districts.

The part of the study in the coastal district was carried out in the experimental orchard of the College of Agriculture, University of Alexandria, on four citrus varieties namely, Baladi sweet orange (*Citrus sinensis,* L.), Baladi mandarin, (*Citrus deliciosa,* Tenore), Clementine tangerine (*Citrus reticulata,* Blanco or probably a hybrid of the mandarin and sour orange (Webber, 1943)) and Sangtra mandarin or Suntara (numerous modifications) of India (Hodgson, 1967).

Five mature trees of each of the above mentioned varieties of almost similar vigour were selected for study in 1968; five Baladi mandarin trees, grown under mature olive trees, were included in order to study the effect of shading on fruit temperature and per cent sunburn. The other part of the study was carried out in the southern Tahrir province (interior district) using four mature trees of each of Baladi sweet orange and Baladi mandarin.

In each district, 10 fruits were selected on each tree from three different locations; two from the interior parts of the tree (shaded fruits); four from the south side of the tree and four from the north side of the tree. The fruits from the south and north sides were exposed to direct sunlight. Thus 40 fruits from each

variety were used for temperature measurements in the interior district and 50 fruits in the coastal district in each temperature measurement. In the Baladi mandarin trees grown under olives; only five fruits were selected from the different parts of each tree and thus the total number of fruits used was 25.

Fruit temperature was recorded on sunny days approximately every two weeks during midday between 12.00 and 14.30 hours in summer and between 11.00 and 13.30 hours in the autumn for calculation of the yearly average fruit temperature. The yearly maximum air temperature was calculated as an average for the same days of fruit temperature measurements.

In fruits exposed to direct sunlight, temperature measurements included temperature of the exposed and opposite flavedo, exposed and opposite albedo and centre of the fruit. In the unexposed fruits, the temperature measurements included the flavedo, the albedo and the centre of the fruit.

For measuring the albedo temperature, a cut parallel to the surface raising a part of the peel approximately 1 mm. in thickness was made with a razor blade making a flap-like piece and a thermometer was inserted to record the temperature.

In 1967, ten additional trees were selected at random in each variety for the determination of the per cent sunburned fruits. Counts were made between November 14 and November 17. In 1968, the percentage of sunburned fruits was calculated approximately every two weeks during the growing season.

Laboratory studies

The tissue culture medium used was that of Nitsch (1951) except for some slight modifications. Vitamins and amino acids were added as suggested by White (1954). Indole acetic acid was added at 1 mg/l, and sucrose 50 g./l. Agar was added to the medium at 8 g./l. The pH was 6.05.

Round discs of peel, 5 mm. in diameter, were removed with a sterile cork borer from fruits that had been surface sterilized with 0.2% mercuric chloride. The plugs were transferred to sterile petri dishes containing filter paper in order to absorb the excess water. The tissue explants were placed individually in test tubes under aseptic conditions on the agar medium. The remaining explants were immersed in a temperature controlled water bath for different periods and at various high temperatures. In addition, 30 round discs were removed from the peel of the same fruits to determine the average fresh weight.

In order to investigate whether there were any anatomical differences due to sunburn, rind samples from both exposed and opposite sides of sunburned fruits were collected on November 15, 1968 and kept in FAA. Sections were cut at ten micron thickness and prepared according to Sass (1951), using the paraffin method. In staining Sharman's (1943) technique was used.

In order to determine the rate of heat gain by fruits of the four varieties, fruits were picked in August (⅔ full size), immersed in hot water at 50°C. and the temperatures at the flavedo, albedo and centre measured.

Results

Field studies

The data of 1967 showed that, in exposed fruits, the yearly average temperature of the albedo of the side of the fruit exposed to the sun was higher than that of the flavedo of the fruit as well as that of the flavedo and albedo of the opposite side of the fruit. The differences were highly significant. This was true in all four varieties (Table 1). Negligible differences in the yearly average temperature were found between the flavedo and albedo of the opposite side of the fruit. The yearly average temperature of the centre of the fruit was higher than that of the opposite albedo and opposite flavedo in all cases and differences were highly significant.

For shaded fruits, the results indicated that the temperature of the flavedo and the albedo in each district was approximately the same and both were significantly higher than that of the centre (Table 1).

In 1968, a similar trend of results was obtained (Table 2). The yearly average temperature of the exposed fruit as a whole in each district and in each year was more or less the same in the four varieties, (Tables 1 and 2).

The results also indicated that the yearly average temperature of the different parts of the exposed fruit was profoundly higher than the average maximum air temperature (Tables 1 and 2). The differences between the exposed albedo and the maximum air temperature reached up to 12.2°C. and 13.3°C. in 1967 and 1968, respectively. Such a trend was not observed in shaded fruits of the same trees. Furthermore, fruit temperatures of Baladi mandarin trees grown under olive trees was consistently lower than that of the Baladi mandarin trees grown in solid blocks, as well as the maximum air temperature (Table 2).

The yearly average temperature of the flavedo, albedo and centre as well as the yearly average temperature of the whole fruit was highest in exposed fruits on the south side of the tree, lower in exposed fruits on the north side and least in the shaded fruits in the interior parts of the tree. The differences were highly significant in all varieties in the two districts (Figs. 1 and 2).

Fruit sunburn started to occur in July in the Baladi mandarin and in August in the Baladi sweet orange and Sangtra mandarin. In some cases the juice vesicles were dry beneath the sunburned side of the Baladi and Sangtra mandarins. No fruit sunburn was observed in the Clementine tangerine and in shaded fruits of the Baladi mandarin. No fruit sunburn was observed in Baladi mandarin trees grown under olive trees either. The highest proportion of sunburned fruits was found on the south side of the tree (Table 3). Higher percentages of sunburned fruits were also observed on small as compared with large Baladi mandarin trees (Table 3).

Laboratory studies

A very rapid increase in temperature of the flavedo and albedo was observed after immersion of the fruit in water. In the Baladi sweet orange, fruit temperature rose from 31.7° to 37.5°C. in the flavedo and from

Table 1
Yearly average temperature of different fruit parts in different citrus varieties, 1967.

Variety	District	Fruits exposed to direct sunlight						Shaded fruits				Max. air temperature
		Exposed		Opposite		Centre	Average	Flavedo	Albedo	Centre	Average	
		Flavedo	Albedo	Flavedo	Albedo							
Baladi sweet orange	Coast[1]	33.04	35.04	31.89	32.12	32.99	33.01	29.57	29.41	28.41	29.13	27.90
	Desert[2]	35.23	36.96	33.88	34.30	34.93	35.06	31.58	31.59	31.08	31.14	31.66
Baladi mandarin	Coast[3]	32.94	34.67	31.41	31.64	33.31	32.79	29.07	28.88	27.78	28.57	27.90
	Desert[4]	34.75	36.49	33.31	33.67	35.17	34.66	31.47	31.28	30.76	31.41	31.66
Sangtra mandarin	Coast[5]	32.87	34.94	31.25	31.47	33.60	32.88	28.87	28.80	27.94	28.54	27.90
Clementine tangerine	Coast[6]	32.69	34.58	31.56	31.53	32.83	32.63	28.96	28.80	28.31	28.69	27.90

LSD for fruit parts

	Exposed		Shaded	
	0.05	0.01	0.05	0.01
(1)	0.353	0.486	0.365	0.541
(2)	0.239	0.335	0.274	0.414
(3)	0.290	0.399	0.253	0.368
(4)	0.324	0.454	0.359	0.544
(5)	0.239	0.329	0.136	0.198
(6)	0.332	0.457	0.161	0.234

Table 2
Yearly average temperature of different fruit parts in different citrus varieties, 1968.

Variety	District	Fruits exposed to direct sunlight						Shaded fruits				Max. air temperature
		Exposed		Opposite		Centre	Average	Flavedo	Albedo	Centre	Average	
		Flavedo	Albedo	Flavedo	Albedo							
Baladi sweet orange	Coast[1]	35.02	36.49	32.95	33.04	34.60	34.42	28.19	28.59	27.76	28.39	28.16
	Desert[2]	37.51	39.17	35.36	35.65	37.21	36.98	31.73	31.63	31.17	31.51	32.14
Baladi mandarin	Coast[3]	35.26	36.78	33.05	33.12	35.13	34.66	28.88	28.93	28.06	28.63	28.16
	Desert[4]	37.35	38.98	35.18	35.43	37.55	36.89	31.73	31.63	31.23	31.51	32.14
Sangtra mandarin	Coast[5]	34.85	36.49	32.93	32.66	34.99	34.38	28.68	28.57	28.15	28.46	28.16
Baladi mandarin under olive trees	Coast[6]	–	–	–	–	–	–	26.79	27.51	26.46	26.80	28.16

LSD for fruit parts

	Exposed		Shaded	
	0.05	0.01	0.05	0.01
(1)	0.154	0.212	0.225	0.327
(2)	0.445	0.639	0.200	0.303
(3)	0.229	0.315	0.428	0.623
(4)	0.280	0.392	–	–
(5)	0.609	0.839	0.353	0.514
(6)	–	–	0.231	0.335

Table 3
Sunburn of citrus fruit in different districts of the Nile Delta, November 1968.

Orchard No.	Variety	Sunburned fruits (% of total fruits)	Sunburned fruits on the south side (% of total sunburned fruits)
I	Baladi mandarin*	11.36	88.98
	Baladi sweet orange	2.60	100.00
II	Baladi mandarin	3.65	84.00
	Baladi mandarin*	16.66	98.00
III	Sangtra mandarin	2.70	100.00
	Baladi sweet orange	1.97	100.00
IV	Baladi mandarin	8.89	78.52
	Sangtra mandarin	2.00	–
V	Clementine tangerine	0.00	0.00
	Baladi sweet orange	0.00	0.00
VI	Baladi mandarin	1.10	100.00
VII	Baladi mandarin*	0.94	100.00
	Baladi mandarin	0.88	100.00
VIII	Baladi sweet orange	1.60	–
	Baladi mandarin	2.08	–
	Sangtra mandarin	1.92	–
	Clementine tangerine	0.00	–
IX	Baladi sweet orange	1.58	–
	Baladi mandarin	1.35	–

* Small size trees.
Orchard I and VIII are in coastal areas, orchard IX is in the desert area and the others are distributed in the Nile valley.

31.9° to 43.9°C. in the albedo in 2.5 min. The maximum increase in temperature of the flavedo and the albedo occurred after approximately 12.5 min. of immersion, after which time no apparent increase was noted. The maximum increase in temperature of the centre, however, was attained after about 25 min. (Fig. 3).

Observations made periodically during the growing season on *in vitro* peel explants of the four varieties showed that the proliferative capacity decreased progressively as the fruit became older (Table 4).

Table 4
Growth in vitro within a period of six weeks of peel discs of different citrus varieties as per cent of the initial weight, 1968.

Variety	Date of planting					
	May 6	June 20	July 9	Aug. 24	Sept. 10	Oct. 14
Clementine tangerine	452.3	360.3	285.2	199.8	241.0	142.0
Baladi mandarin	443.9	344.7	223.2	151.4	175.0	147.3
Baladi sweet orange	380.3	338.4	340.4	184.4	219.0	254.4
Sangtra mandarin	599.0	272.8	–	171.3	210.0	156.0

The results obtained as regards *in vitro* growth of fruit peel that had been subjected to 50°C. for different periods and then incubated at 25°C. for five weeks are shown in (Table 5). The results generally indicated that growth of the treated explants of the four varieties is decreased as compared with the untreated explants.

Table 5
Effect of exposure 50°C on growth of citrus fruit peel in vitro during a 5 weeks period after the high temperature treatment, as a per cent of the untreated (control), 1968.

Date of planting	Time of exposure (min.)	Varieties			
		Baladi sweet orange	Sangtra mandarin	Baladi mandarin	Clementine tangerine
	30	80.2	73.9	99.7	84.6
May 6	40	66.9	76.9	82.4	76.4
	50	69.8	63.0	93.5	70.6
September 10	60	90.0	81.8	67.5	58.0
	70	77.1	66.6	70.8	69.0

N.B. (a) No killing was observed in the May 6 experiment.
(b) No killing was observed in the Sangtra mandarin and Clementine tangerine in the September 10 experiment; for killing in the other two varieties see table 6.

The results of the exposure of peel discs to 50, 55 or 60°C. showed that Baladi mandarin tissue was the most and Clementine tangerine the least injured by the treatment, the other varieties being intermediate (Table 6). It was further noted that the per cent killing increased, as expected, with increased temperature or time of exposure (Table 6).

Table 6
Per cent killing in citrus peel explants as a result of exposure to different temperatures for different periods, 1968.

Date of planting	Water bath temperature	Time of exposure (min.)	Baladi sweet orange	Sangtra mandarin	Baladi mandarin	Clementine tangerine
September 10	50	60	0.0	0.0	18.2	0.0
		70	8.3	0.0	20.0	0.0
October 14	50	80	61.5	50.0	100.0	0.0
		90	50.5	46.6	100.0	11.7
		10	6.6	13.3	40.0	0.0
October 24	55	30	66.6	81.0	100.0	78.6
		40	100.0	100.0	100.0	64.7
		5	100.0	100.0	100.0	13.1
October 1	60	10	100.0	100.0	100.0	81.0
		15	100.0	100.0	100.0	100.0

The anatomical structure of the rind in both the sunburned side and the normal opposite side of the same fruit in the different varieties was studied. No anatomical differences were found between normal and sunburned sides in the different varieties except in the Baladi mandarin fruits where about nine peripheral corky layers were observed in the epiderm, hypoderm, and outer mesocarp in the sunburned area. Such corky layers were observed neither in the shaded side of the same fruit nor in the sunburned fruits of the other varieties.

Discussion

The results obtained in the present study show that there is a highly significant interaction between location of the fruit, date of temperature measurement and temperature of the different parts of the fruit.

It was observed that the exposure of the fruit to sunlight rapidly increases its temperature. This observation is in agreement with those made when detached fruits were immersed in water maintained at 50°C., when internal temperatures rose within minutes of immersion.

The results of the present study and of other investigations (Hopp, 1947; Turrell and Boyce, 1953; Schroeder, 1965; Cooper, 1967; Coursey, 1968) show that parts of plant organs exposed to direct sunlight were higher in temperature than shaded parts. The data also show that the temperatures of the different parts of the fruits which were exposed to the sun were higher than the maximum air temperatures. The difference was greater on the exposed side of the fruit. In some extreme cases the temperature of the exposed albedo was 13.3°C. above

the maximum air temperature. It might, thus, be expected that the biochemical processes on the exposed side of the fruit are affected differently from those on the opposite side: there might similarly be differences between fruits on the south and north sides of the tree as well as between exposed and shaded fruits in general. These differences might be responsible for certain injuries that occur on the exposed sides of fruit, such as sunburn. Turrell and Boyce (1953) on lemon fruits suggested that injurious fruit-peel temperature may be due to an unfavourable ratio of energy received to energy lost by fruit and that warm air may be primary factor interfering with heat dissipation by the fruit. On the other hand, Maxie and Claypool (1957), working on prunes, and Coursey (1968), on yam tubers in storage, have suggested that anaerobic conditions brought about by enhanced respiration rates at high temperatures may occur at the cellular level.

The results also revealed that the temperatures of all parts of the fruit at different locations on the tree was lowest on the shaded locations, intermediate on the north, and highest on the south side of the tree. The differences were highly significant. Thus, one might expect injury to occur to fruits in certain locations only on the tree, and it was observed that the highest proportion of sunburned fruits occur on the south side of the tree. These results are in line with those of Turrell and Boyce (1953) and Ketchie and Ballard (1968). This may be due to the expected higher intensity and longer duration of radiation on the south side of the tree.

The results also showed that there was no fruit sunburn on the shaded parts of the trees in any varieties or in Baladi mandarin grown under olive trees. This is in line with fruit temperature data, and could be explained in view of the results obtained by Heinicke (1963; 1964) and Looney (1968) who found that light density dropped rapidly with increasing depth of foliage and that as tree size increased, shading and leaf area per tree increased. These observations might also explain the higher percentage of sunburned fruits produced on small than on large trees.

The percentage of sunburned fruits was lower in the desert than in the coastal area although the maximum air temperature in the former was the higher. These results are in agreement with Turrell *et al.* (1964). The relative humidity in the desert area was however lower. The temperatures of the exposed fruits, especially the exposed parts, were much higher than the air temperature, the effect being more marked in the coast than in the desert possibly because the higher humidity inhibited loss of heat by transpiration. This result is in line with Raschke (1960).

In vitro studies with peel discs showed that proliferative capacity decreased with increasing fruit age. Further, it was shown that exposure of peel explants of the four experimental varieties to a temperature of 50°C. followed by incubation at 25°C. reduced growth compared with control explants. The effect of the treatment was still evident five weeks after the explants were exposed to 50°C. for only 30 - 70 min. If this were true for intact fruits on the tree it might mean that abnormally high temperatures even those which do not cause sunburn, might reduce fruit growth, at least on the side of the fruit facing the sun, providing that the temperature does not rise to the extent that would cause fruit abscission. These results, in fact, give an explanation to the observation made by Ketchie and Ballard (1968) concerning reduction in size of fruits fully exposed to the sun as compared with those growing in the shade.

As regards the tolerance of the four varieties to high temperature *in vitro,* the results generally showed that Baladi mandarin fruit peel explants were the least tolerant to high temperature whereas the Clementine tangerine was the most tolerant. Baladi sweet orange and Sangtra mandarin were intermediate. This explains the fact that although fruits of all four varieties reached the same temperature on the tree, yet they differed in the per cent sunburn. It seems that the difference between these four varieties in the per cent sunburn is a matter of difference in heat tolerance rather than in peel temperature. The Baladi mandarin fruit was the least tolerant to heat *in vitro* and at the same time the most subject to sunburn. On the other hand, the Clementine tangerine which was the most tolerant to heat *in vitro,* showed no fruit sunburn in the field. The other varieties was intermediate in both respects.

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Figure 1

Seasonal changes in fruit temperature as affected by location on the tree, Alexandria 1968

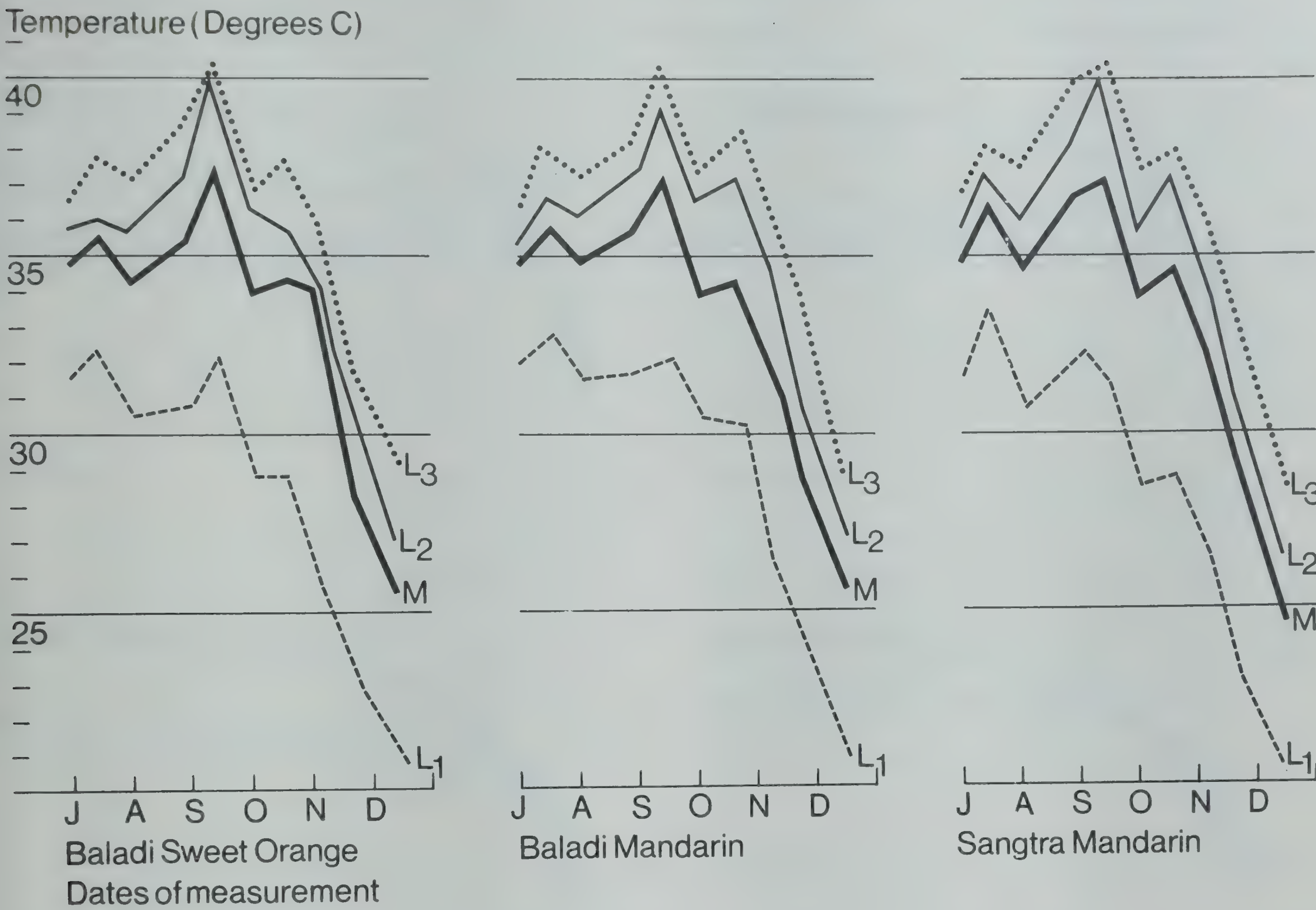
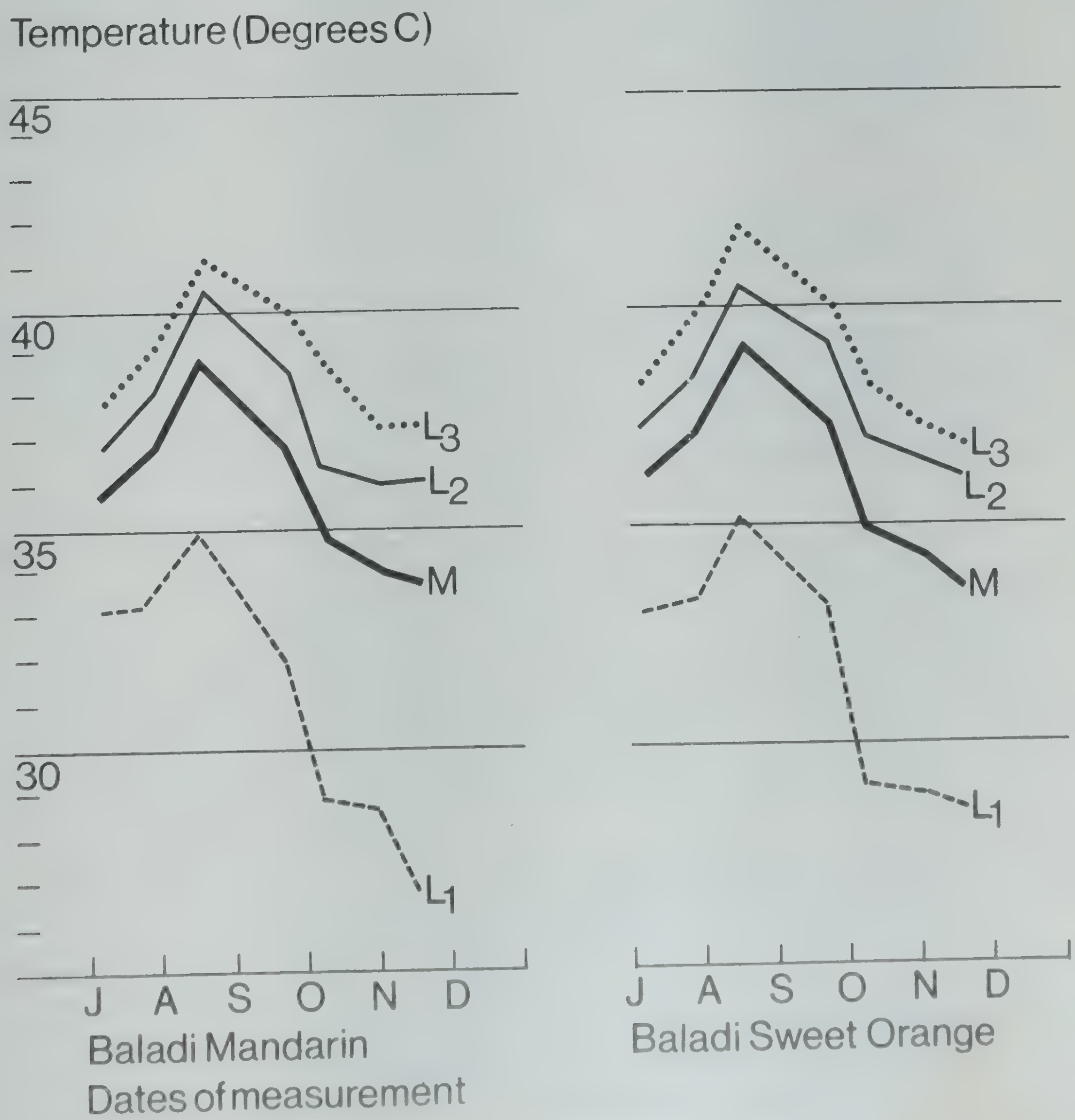


Figure 2

Seasonal changes in fruit temperature as affected by location on the tree, Tahrir 1968



Key to figures 1 and 2

Shaded fruits from interior parts L_1

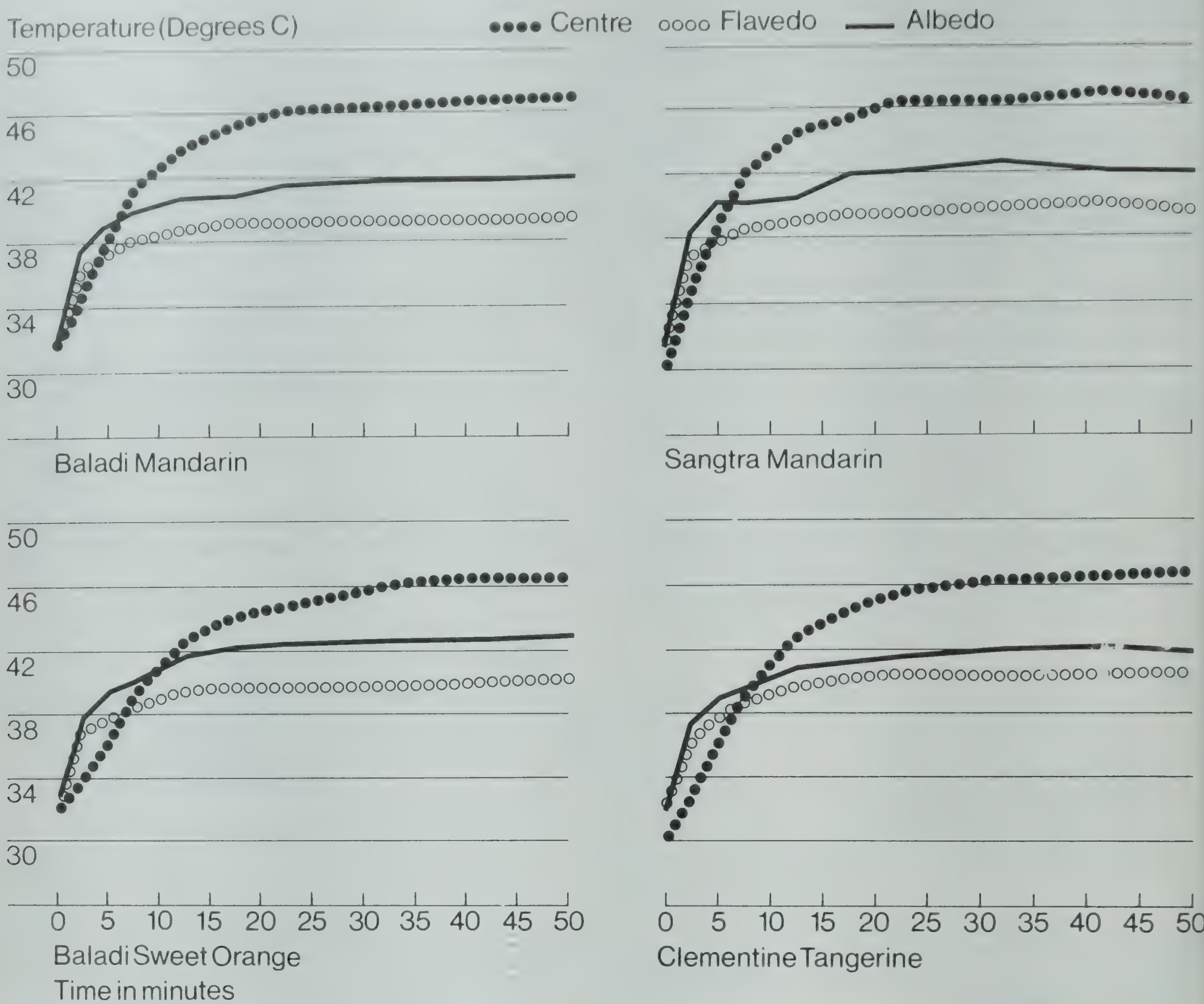
Exposed fruits from north side L_2

Exposed fruits from south side L_3

Average of all locations M

Figure 3

Temperature changes flavedo, albedo and centre of fruits immersed in water bath maintained at 122°F



Nutritional status of citrus trees in Lebanon

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Summary

Leaf and soil inorganic analyses were carried out in 66 Lebanese citrus orchards during the summer of 1966 to establish the nutritional status of citrus. The orange varieties Shamouti, Valencia, and Washington Navel and Mediterranean Mandarin and Sa'asly lemons were sampled. Pertinent data on cultural practices for the 3 years preceeding the sampling were compiled. All leaf samples were assessed for total N, P, K, Ca, Mg, Na, Fe, B, Zn, Mn and Cu. Calcium carbonate and pH were determined for the soil samples.

Most orchard owners used ammonium sulphate, goat manure, and super-phosphate (18% P_2O_5) though in widely differing amounts. Soil $CaCO_3$ was very high and the soil pH ranged from 7.3 to 8.1.

Results of tissue inorganic analysis were compared with conventional standards which indicated that leaf N and K contents were generally low. Leaf P was somewhat below the satisfactory range. The majority of the orchards were either 'deficient' or 'low' in Mg, Zn, Mn, also low in Cu to a lesser extent; calcium and Na were either 'high' or in 'excess' with Fe and B present in 'sufficient' amounts.

It was apparent that excess soil Ca and a constant water shortage have resulted in reduced K and Mg levels in tree tissue and high P fertilizer application resulted in reduced levels of Zn and Mn in the leaves.

Introduction

Field observations pointed out the possible existence of nutritional disorders in citrus orchards in Lebanon. For this reason the following study was undertaken to determine the nutritional status of Lebanese citrus orchards with regard to eleven elements, as related to local cultural practices, particularly fertilization programmes.

Materials and Methods

Sixty six orchards along the citrus belt of Lebanon were chosen at random. Leaf samples were collected from three or six trees in each orchard depending on the size of the orchard. Varieties sampled were mainly Shammouti, Valencia and Washington Navel orange. Some samples were collected from Mediterranean Mandarins and Sa'asly lemons. All trees sampled were on sour orange rootstocks.

Leaf sampling was carried out between August 10th and September 16th, 1966. Records on cultural practices for each orchard between 1963 and 1966 were kept. The samples were collected according to the recommendations of Chapman (1960) and Steyn (1960). The leaves were prepared for analysis according to the methods suggested by Labanauskas (1966); Smith *et al.* (1950) and Willson (1961).

Leaves were analyzed for total N by the modified Kjeldahl method (Jackson, 1958). Boron was assessed by the method advanced by Johnson and Ulrich (1959). Leaf P, Mg, Fe, K. Ca and Na were analyzed according to the method of Toth *et al.* (1948). Zinc, Mn and Cu were determined by a Model 303 Perkin Elmer Atomic Absorption Spectrophotometer according to the manufacturer's instructions.

The provisional set of standards suggested by Chapman (1966) for citrus leaf analysis were used to evaluate the results obtained in this study.

The soils in all orchards surveyed were found calcareous in nature with $CaCO_3$ contents ranging from 1.84% to 58.37%. The pH values varied from 7.3 to 8.1.

Only mean analytical values, referred to hereafter as mean values, are reported. Each of these values represents the average for 3 or 6 leaf samples.

Nitrogen

By studying table 1 it was apparent that the mean values for leaf N varied from 1.44% to 2.58%. The lower mean value indicated a deficiency according to Chapman (1966). By grouping the results of all orchards (Table 2 and Figure 1), it was revealed that about 55% of the orchards in this study were either 'low' or 'deficient' in N, while the rest were found to fall in the 'satisfactory' range. Lemon trees were found consistently 'deficient' in N. Visual observations on the lemons showed typical N deficiency and flowering, bearing out the suggestion of Embleton *et al.* (1959) that N deficiency in plants is associated with fruitfulness.

The orchard records for lemons showed that the low leaf N was not related to the amount of N fertilization. Since it is a practice to force flowers by withholding water in early summer, this practice might have contributed to the low leaf N, since the trees were in no position to take up soil N due to shortage of water.

Phosphorus

The mean values for leaf P in this study ranged from 0.09% to 0.23% (Table 1). These values showed that one third of the orchards had low leaf P while the remaining groves were in the 'satisfactory' range, except for two orchards where P was found 'high' (Table 2 and Figure 1). The records maintained on cultural practices, revealed that 25% of the orchards were not supplied with P fertilizers between the years 1963 and 1966, yet trees in these orchards were neither 'deficient' in P nor were they strikingly different in leaf P content from the trees receiving regular high amounts of P fertilizers. These latter findings were in agreement with results found elsewhere (Embleton *et al.*, 1956; Harding, 1953; Reuther *et al.*, 1949; Smith, 1966).

Potassium

Leaf K mean values in this study ranged from 0.24% to 1.35% (Table 1). Table 2 and Figure 1 show that 77% of these values were in the 'low' range, 3% in the 'deficient' range and the remainder were in the 'satisfactory' range. A large proportion of the orchards in the 'low' range were receiving K fertilizers either as muriate or from compound fertilizers. These orchards were not substantially different in their leaf K values from orchards not receiving K fertilizers between the years 1963 and 1966. The 'low' leaf K could be attributed to the calcareous nature of the soil (Smith, 1966).

Calcium

Calcium was found 'high' in the leaf tissue and mean values ranged from 4.80% to 9.64% (Table 1). By referring to table 2 and figure 1, it was apparent that 44% of the samples were in the 'high' range, 36% in the 'excess' range, and the remaining were in the 'satisfactory' range. The excess leaf Ca is attributed to the calcareous nature of the soils and is probably one of the major factors causing nutritional disorders.

Magnesium

Magnesium in the leaves was generally 'low' and the mean values ranged from 0.08% to 0.45% (Table 1). Only 12% of these values were in the 'satisfactory' range, while the rest were either 'low' or 'deficient' (Table 2 and Figure 1). Almost every orchard in this study had leaves showing interveinal or marginal chlorosis which was more apparent in the older leaves. These patterns of chlorosis are typical Mg deficiency symptons (Chapman, 1966). 'Low' leaf Mg could be attributed to the high soil Ca, which is known to antagonize Mg uptake (Smith, 1966).

Sodium

Leaf Na ranged from 0.02% to 0.41% (Table 1). Table 2 and Figure 1 show that 51.5% of the mean values were in the 'high' or 'excess' ranges, about 40% were in the 'satisfactory' range while the remainder were in the 'low' range. The generally high content of Na in the leaves could not be attributed to fertilization since sodium nitrate was used in only 3 orchards. No other Na carriers were recorded to be in use in any of the other orchards between the years 1963 and 1966. Moreover, the characteristic symptoms of Na toxicity (Chapman, 1966) were not observed in any of the orchards. It was suggested (Smith, 1962) that no definite range is established for Na toxicity. Since citrus leaves absorb Na readily (Chapman, 1966), it is possible that the generally high Na in the leaves was due to sodium salts in the sea spray carried to the orchards which were 500 to 2,000 m away from the sea. Similar observations were reported by Reitz and Long (1953).

Iron

Iron ranged from 50 to 194 ppm (Table 1). Ninety four percent of the surveyed orchards were in the 'satisfactory' range while the remaining 6% were either 'low' or 'high' in Fe (Table 2 and Figure 2). These findings indicated that Fe was not a nutritional problem in the sampled orchards.

Boron

Boron contents ranged from 54 to 167 ppm (Table 1) and B was 'satisfactory' in all orchards surveyed (Table 2 and Figure 2). By comparing leaf B to leaf Ca (Table 1)

it was found that high B was associated with high Ca. This observation is in agreement with the findings of Jones and Scarseth (1944).

Zinc

The leaf Zn mean values ranged from 11 to 235 ppm (Table 1). Table 2 and Figure 2 show that 76% of the surveyed orchards were either 'low' or 'deficient' in Zn, while 21% were 'satisfactory'. There were 2 orchards where Zn was found to be exceedingly 'high' in all samples (i.e. 111 ppm and 235 ppm average) for which no explanation was found.

The 'low' Zn in the leaves appears to be due to the calcareous nature of the soil and the continuous application of superphosphate fertilizers (Bingham and Martin, 1956; Labanauskas *et al.* 1960). This is further linked with the soil pH which was between 7 and 8, where Zn solubility in soils is minimum (Jurinak and Thorne, 1955).

Manganese

Mean Mn in leaves ranged from 7 to 45 ppm (Table 1). As shown in table 2 and figure 2, it was found that 62% of Mn mean values were in the 'deficient' range, about 20% in the 'low' range and the remaining values were in the 'satisfactory' range. It was reported that a pH of 6.5 or above in calcareous soils causes an oxidation of the manganous forms to the manganic forms of this element, thus rendering it unavailable to the plant in sufficient amounts (Chapman, 1966). Also it was reported that high lime in the soil induces Mn deficiency in citrus (Labanauskas *et al.*, 1962). Since ammonium sulphate was the most commonly used N fertilizer in the orchards under study and in view of the calcarous nature and high pH values of the soils, these conditions probably contributed to the occurrence of the Mn deficiency.

Copper

There was a great difference in the contents of leaf Cu which ranged from 3 to 29 ppm (Table 1). Table 2 and Figure 2 show that almost 50% of the orchards were 'low' in Cu, 47% were in the 'satisfactory' range while the remaining few were either 'high' or 'deficient'. Although P fertilizers were applied continuously between the years 1963 and 1966 in 75% of the surveyed orchards, only 2 orchards were found to be deficient in Cu. The latter observation does not concur with reported findings that phosphatic fertilizers applied to citrus trees induced Cu deficiency. (Bingham *et al.*, 1958; Spencer, 1960).

Summary

A survey was conducted on the nutritional status of a representative sample of Lebanese citrus orchards with regard to the leaf inorganic constituents N, P, K, Ca, Mg, Na, Fe, B, Zn, Mn, and Cu, as compared to currently available conventional standards of citrus leaf analysis.

Leaf analyses were carried out on 372 leaf samples collected between August 10th and September 16th, 1966 from 66 citrus orchards located on the coastal area of Lebanon. Information on the cultural practices followed in the orchards between the years 1963 and 1966 was compiled.

The $CaCO_3$ contents in the soils indicated that all the orchards surveyed had calcareous soils with pH values ranging from 7.3 to 8.1.

On comparing the results of leaf inorganic constituents obtained in this study with those of conventional leaf standards for citrus, it was found that N and K tended to be 'low'. A similar tendency, but to a lesser extent, was observed for leaf P. The majority of the trees studied were either 'deficient' or 'low' in leaf Mg, Zn, and Mn, and to a lesser extent in Cu, whereas leaf Ca and Na were either 'high' or 'in excess' in most of the cases. All the orchards surveyed seemed to have no nutritional problem concerning Fe or B.

The results of this study indicated that the calcareous nature of the soil and the high pH, coupled with continuous use of superphosphate, indiscriminate use of ammonium sulphate, and the prolonged irrigation intervals, had upset the nutritional balance of the trees, in particular affecting the levels of leaf K, Mg, Zn, Mn and Cu in the leaves.

Acknowledgements

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Table 1.
Citrus leaf composition (dry weight) of N, P, K, Mg, Ca, Na, Fe, B, Zn, Mn and Cu from the 66 orchards, tabulated according to species and varieties. (Means for 3 or 6 sampled trees from every orchard).

Orchard[a] No.	N %	P %	K %	Ca %	Mg %	Na %	Fe (ppm)	B (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
Shammouti oranges											
1	2.00	0.09	0.64	7.40	0.19	0.13	68	67	15	15	5
2	2.18	0.10	0.69	6.54	0.19	0.19	92	82	16	22	6
3	2.31	0.11	1.03	5.75	0.17	0.13	72	66	17	14	6
4	1.97	0.10	0.85	6.64	0.13	0.20	91	54	16	13	6
5	2.17	0.12	0.95	5.94	0.18	0.38	76	90	14	13	5
6	2.25	0.17	1.31	6.22	0.18	0.12	70	59	16	14	5
7	1.98	0.13	1.10	6.49	0.16	0.21	94	65	14	12	5
8	2.00	0.12	0.66	6.82	0.16	0.24	107	64	18	15	10
9	1.91	0.12	0.84	6.11	0.15	0.19	142	55	38	12	8
10	2.00	0.12	0.96	5.15	0.16	0.28	81	66	13	13	8
11	2.32	0.12	1.20	5.18	0.19	0.21	99	86	17	11	5
12	2.29	0.11	0.97	5.90	0.12	0.14	119	77	11	10	8
13	2.14	0.17	1.35	6.52	0.12	0.16	138	90	12	7	6
14	2.17	0.12	0.94	6.17	0.14	0.28	100	100	13	17	5
15	2.07	0.23	1.12	6.04	0.17	0.33	85	54	19	13	5
16	1.82	0.14	0.75	6.98	0.14	0.38	79	85	19	10	13
17	2.08	0.15	0.83	6.94	0.15	0.22	87	90	14	16	5
18	2.02	0.10	1.10	6.40	0.11	0.16	82	80	11	10	4
19	1.96	0.11	1.12	6.82	0.08	0.19	77	92	29	12	6
20	2.00	0.11	1.15	6.10	0.10	0.16	82	84	13	10	5
21	1.99	0.13	1.21	7.55	0.09	0.14	75	85	13	12	4
22	2.12	0.12	0.93	6.83	0.13	0.28	74	82	14	9	5
23	2.20	0.14	0.92	5.84	0.16	0.21	83	72	13	12	4
24	2.09	0.13	1.02	5.09	0.13	0.13	75	74	13	12	4
25	2.17	0.13	0.52	5.89	0.27	0.41	79	96	26	17	5
26	2.06	0.13	0.86	6.48	0.23	0.21	75	75	15	29	3
27	2.09	0.16	0.94	6.10	0.16	0.18	74	115	49	21	4
28	1.97	0.12	0.65	7.36	0.15	0.14	64	126	98	30	4
Valencia oranges											
29	1.93	0.10	0.45	7.69	0.14	0.18	99	86	54	24	8
30	2.25	0.13	0.81	5.82	0.43	0.21	121	94	84	33	7
31	1.99	0.11	0.78	6.76	0.43	0.10	121	101	26	43	5
32[a]	2.27	0.22	1.27	4.80	0.27	0.29	93	89	13	20	7
33	2.12	0.13	0.74	8.37	0.22	0.12	68	123	22	28	5
34	2.32	0.12	0.51	7.24	0.16	0.08	64	95	16	28	6
35	2.18	0.13	0.63	7.19	0.16	0.16	62	86	21	26	5
36	2.17	0.14	0.62	8.30	0.17	0.17	55	114	13	25	7
37	2.38	0.14	0.56	7.46	0.20	0.17	62	84	16	18	4
38	2.41	0.13	0.39	7.57	0.30	0.32	90	86	16	29	5
39	2.20	0.12	0.41	7.61	0.21	0.13	64	100	36	26	7
40	1.86	0.11	0.41	9.64	0.20	0.11	62	129	13	20	5

Table 1. (*continued*)
Citrus leaf composition (dry weight) of N, P, K, Mg, Ca, Na, Fe, B, Zn, Mn and Cu from the 66 orchards, tabulated according to species and varieties. (Means for 3 or 6 sampled trees from every orchard).

Orchard[a] No.	N %	P %	K %	Ca %	Mg %	Na %	Fe (ppm)	B (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
Valencia oranges (continued)											
41	1.90	0.13	0.48	6.78	0.21	0.14	74	90	111	16	6
42	2.58	0.12	0.45	6.81	0.18	0.24	71	115	14	21	7
43	2.03	0.11	0.42	8.06	0.25	0.18	81	118	13	16	7
44[a]	2.34	0.13	0.97	6.78	0.45	0.13	107	103	19	40	6
45[a]	2.58	0.12	0.62	5.77	0.16	0.39	83	68	13	11	6
46	2.16	0.12	0.62	6.99	0.20	0.17	95	88	17	31	4
47	2.50	0.14	0.75	6.38	0.15	0.19	70	98	25	21	8
48	2.25	0.11	0.51	7.46	0.15	0.08	96	88	13	18	4
49	2.27	0.13	0.71	7.51	0.10	0.17	92	102	14	24	7
50	2.11	0.14	1.05	6.78	0.15	0.15	86	102	16	30	7
Mandarin											
51[a]	2.25	0.12	0.64	6.97	0.22	0.28	157	96	14	15	5
52[a]	2.02	0.09	0.65	6.61	0.15	0.21	52	90	17	23	8
53[a]	2.19	0.11	0.24	6.80	0.17	0.14	100	136	27	19	10
54	2.36	0.13	0.78	6.70	0.18	0.32	85	88	15	12	3
55[a]	2.13	0.12	0.55	7.17	0.14	0.14	61	96	11	15	9
56	2.50	0.12	0.52	5.90	0.20	0.39	72	92	22	13	5
57	2.10	0.11	0.35	5.77	0.23	0.13	69	89	15	15	5
58[a]	2.15	0.11	0.29	8.02	0.24	0.19	194	108	14	22	5
59	2.31	0.11	1.01	6.99	0.13	0.24	83	107	17	8	5
60	2.42	0.14	0.58	7.11	0.25	0.07	79	153	16	22	6
Sa'asly lemons											
61	1.44	0.13	0.69	8.10	0.11	0.02	70	125	50	24	29
62	1.64	0.10	0.64	7.86	0.18	0.04	98	167	48	15	13
63	1.69	0.10	0.45	7.84	0.15	0.03	74	156	66	16	15
64	1.66	0.12	0.41	7.71	0.23	0.04	90	100	39	20	14
65	1.80	0.15	0.62	5.11	0.18	0.21	85	92	17	14	12
66	1.84	0.11	0.49	8.43	0.21	0.12	74	109	235	15	7

[a] Suffix at the right of some orchard numbers indicate that each of these values represents the mean of analyses for 3 trees.

Table 2.
The nutritional status of 66 citrus orchards in Lebanon, distributed with respect to the conventional ranges of 11 elements in the leaves according to Chapman (1966)

Element	Deficient		Low		Satisfactory		High		Excess	
	orchards	%	orchards	%	orchards	%	orchards	%	orchards	%
Boron (B)					66	100.0				
Calcium (Ca)					13	19.7	29	43.9	24	36.4
Copper (Cu)	2	3.0	32	48.5	31	47.0			1	1.5
Iron (Fe)			3	4.6	62	93.9	1	1.5		
Magnesium (Mg)	22	33.3	36	54.6	8	12.1				
Manganese (Mn)	41	62.1	13	19.7	12	18.2				
Nitrogen (N)	9	13.6	27	40.9	30	45.5				
Phosphorus (P)			22	33.3	42	63.7	2	3.0		
Potassium (K)	2	3.0	51	77.3	13	19.7				
Sodium (Na)			6	9.1	26	39.4	20	30.3	14	21.2
Zinc (Zn)	25	37.9	25	37.9	14	21.2	1	1.5	1	1.5

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Figure 1

The nutritional status of 66 citrus orchards in Lebanon with respect to the conventional ranges of N, P, K, Mg, Ca, and Na in the leaves.

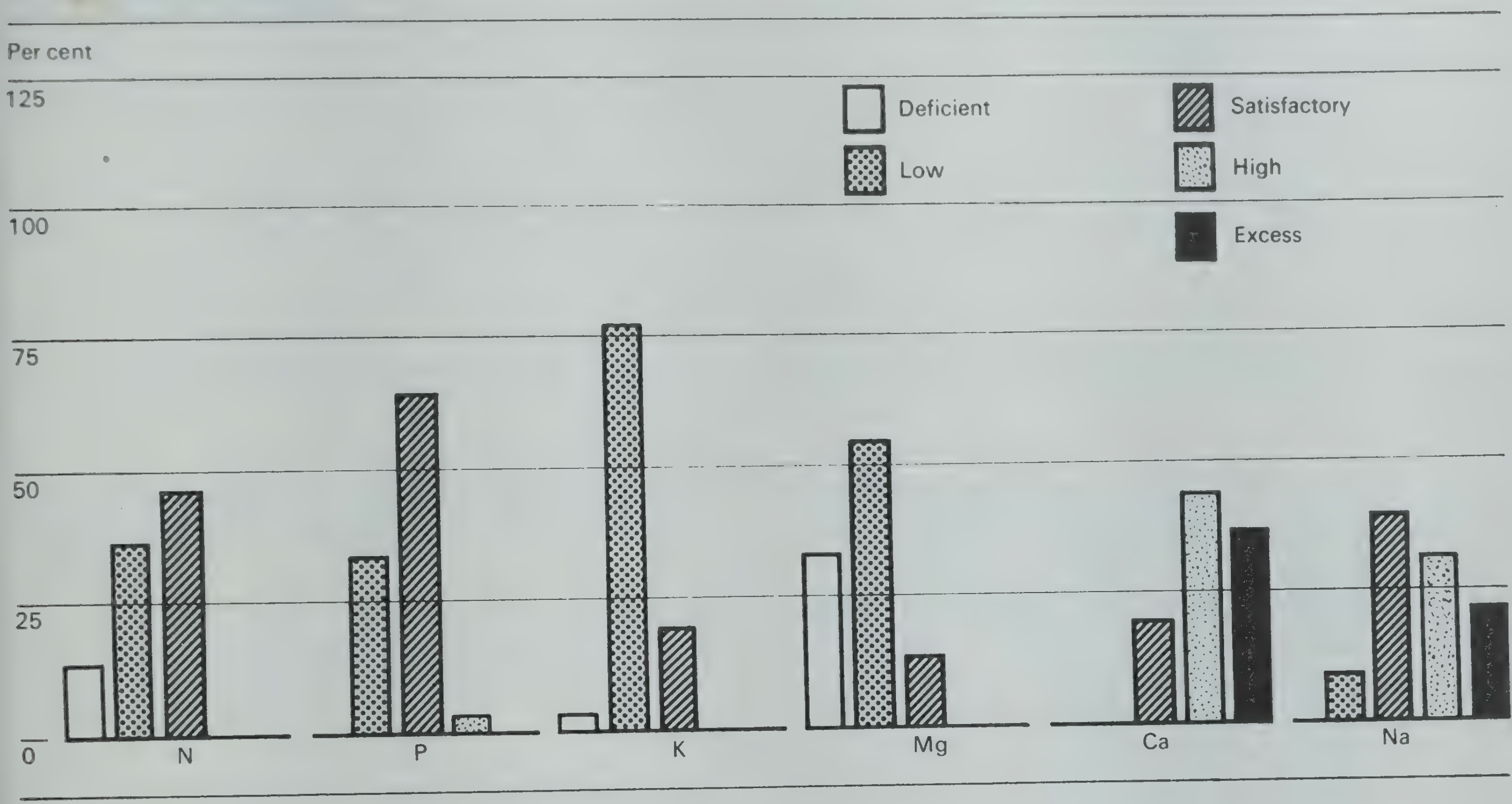
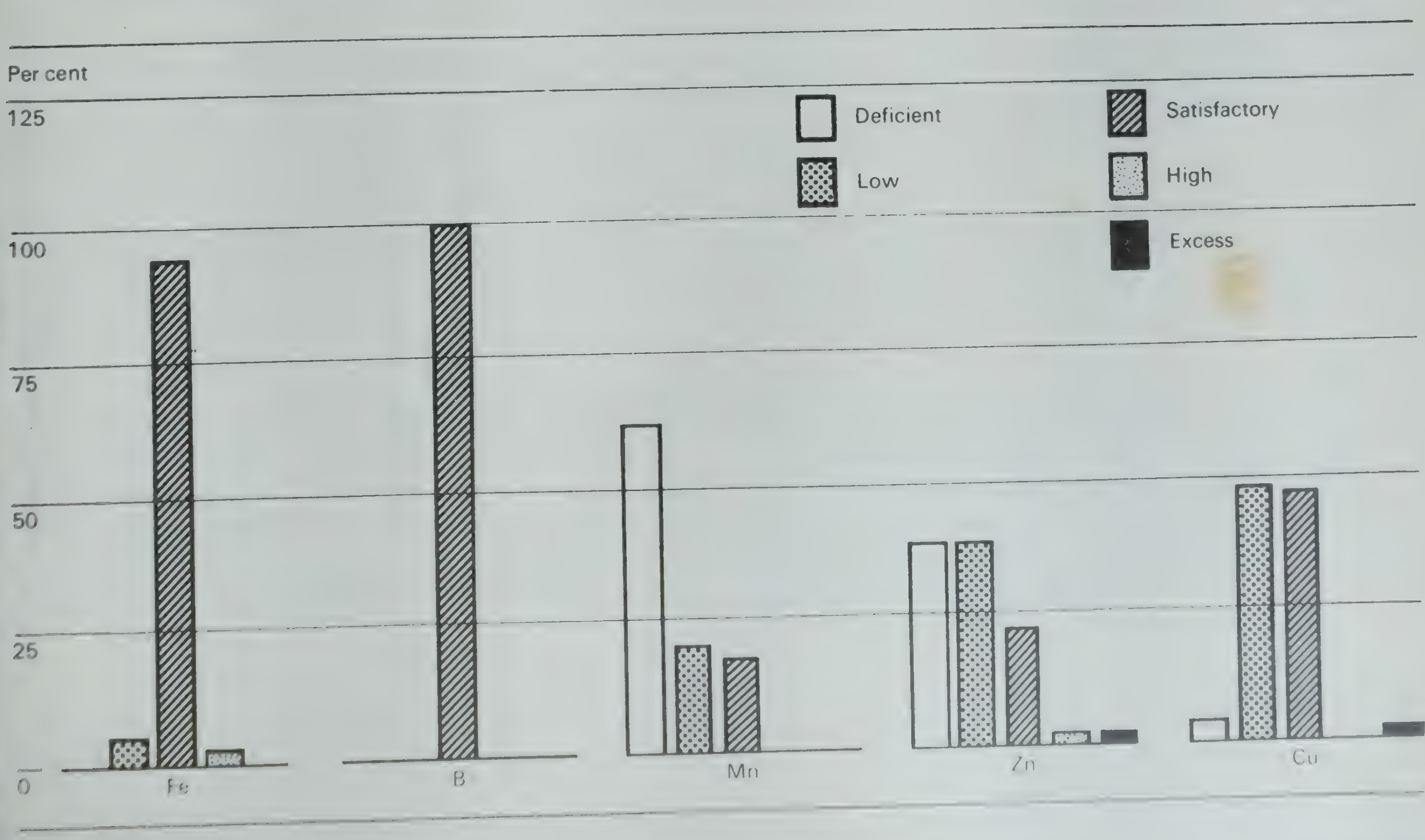


Figure 2

The nutritional status of 66 citrus orchards in Lebanon with respect to the conventional ranges of Fe, B, Mn, Zn, and Cu in the leaves.



Discussion

Dr. Khalidy: What size of plastic container is used for plant seedlings, and what age are the seedlings wedge grafted?

Prof. Tai: The containers were the equivalent of 15 cm pots and the seedlings no older than a fortnight after emergence of the shoot.

Mr. Alles: I would like to know more about processing of rambutan.

Dr. Stanton: I personally have not conducted any processing myself of these fruits but limited experiments on canning have been conducted. One of the difficulties is de-seeding.

M. Frossard: Existe-t-il à Trinidad un problème de pourritures de racines de l'avocatier? Où *Phytophthora,* car c'est un problème très grave en Californie et en Afrique, par example.

Prof. Tai: This is a universal problem, and we can only grow the avocado successfully on the better drained soils.

Dr. Jongeleon: An important consideration in the study of tropical fruits is the role they play in the nutrition of local people. Research should be directed to find ways to process and distribute fruit products that may help to overcome the deficit in minerals and vitamins, and to convince people of the tropical areas of the importance of fruit consumption. Emphasis should be put in the study of native fruits not only for export purposes but for local use.

Mr. Coursey: Dr. Minnessy's paper has drawn attention to some matters which are of importance, quite beyond the field of citrus scald. These are related to the question of the temperatures attained in produce when exposed to insolation in the tropics. Many people assume, incorrectly, that if the ambient temperature is, say, 30°C, then anything kept under those ambient conditions must be at the same temperature: Dr. Minessy has shown that even fairly light coloured fruit such as citrus can be raised by insolation to considerably higher temperatures: I myself have recorded temperatures as high as 51°C in darker coloured material (root crops) stored under insolation in West Africa. These high temperatures obviously have implications in many post-harvest situations, e.g. the question of removal of field heat. I would like to draw attention to some work done in America of desert plants: those with thin leaves, which could lose heat through transpiration, remained near ambient under insolation while those with bulky organs, such as *Opuntia,* reached much higher temperatures. It has been suggested that this effect may be associated with biochemical differences, and it is interesting to note that it is mainly in bulky plants that the crassulacean acid metabolism is observed. To come back to the fruit field, it may be noted that this type of metabolism has recently been observed in pineapples.

On Dr. Khalidy's paper, I would like to question whether high Na levels are really associated with sea spray, unless the trees are within a few hundred metres of the sea. Some measurements of atmospheric salinity behind a surf beach in West Africa showed a very high sodium level close to the sea, but within a few hundred meters, it had dropped off to a near-normal level.

Dr. Khalidy: The nearest orchard surveyed was 500 metres, and the farthest two kilometres away from sea. After some winter storms we have noticed salt injury to leaves of citrus trees when they are close to the coast.

Dr. Gazit: I have to contradict Mr. Coursey's remarks about sodium levels in the atmosphere. In Israel, up to two kilometres from the sea we found an appreciable amount of sodium chloride in the atmosphere. Trees have been scorched by salt spray up to two or three kilometres inland. We do not recommend planting orchards nearer than two kilometres to the shore.

Ninth Session

Friday 19th September
Morning

Chairman
Dr. J. C. Fidler
Head of Fruit Storage Section,
East Malling Research Station

Codex Alimentarius and its' work on fruit standards

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Summary

The background to international food standards is described together with a brief resume of pre-Codex work.

The structure and organization of the Codex Alimentarius Commission and its origins is discussed, together with an introduction to its aims and method of working.

Fruit standards are the concern of certain specialist Commodity Committees within the framework of Codex, those dealing with quick frozen foods, processed (including dried) foods and fruit juices being of particular importance. Cooperative projects with the Economic Commission for Europe (ECE) are also extant, notably in connection with fresh fruit (e.g. apples).

The standards at present in the pipeline in connection with fruit are described, together with mention of the general Committees of Codex (e.g. hygiene, labelling, additives, pesticide residues and methods of analysis) and a brief description of the relationship of these latter bodies to the Commodity Committees dealing with fruit.

The future of Codex Alimentarius is discussed finally, and its effects on national legislations and international trade assessed.

Almost all countries of the world recognize the need for consumer protection, and in the field of food standards, the necessity both for the protection of health and for the prevention of deception is very real. Since consumer protection is regarded as an essential function of governments, particularly in developed countries a large body of law and regulations are now extant.

However well national legislation is drafted, it is almost certain that it will adversely affect the freedom of international trade. The more sophisticated a particular country becomes in respect of legislative control, the more likelihood exists that it will settle for different provisions from its neighbours. It then becomes that much less easy to trade in foods of exactly the same composition between different countries. This, of course ignores the other potential use of food standards, as a sophisticated method of economic protection.

Clearly therefore if consumer protection preoccupies governments, and if trade in food is to flourish at the same time, discipline must be exercised on the basis of international agreement. Developing countries, particularly those of recent independent status will all, no doubt, wish to introduce their own food standards legislation. Unless some pattern can be devised they may seriously prejudice their own chances of a successful trade and to some extent, the chances of other trading nations as well.

The need for some international agreement in food standards is therefore transparently clear for food producers, traders, consumers and Nations. If good food standards can be elaborated, it is to be expected that developing countries will be willing to adopt them without much alteration, or at least to use them as a working basis for their own regulations.

Today there is general agreement on the need for international standards, but this does not by any means automatically ensure that those standards are easy to obtain. As the current Chairman of the Codex Alimentarius Commission has said (Davies, 1968), it is easy to keep everybody together on the large print, but there is a great deal of small print in food standards. The danger is ever present that a concentrated enthusiasm for international food standards may turn out to be a passion for standards for their own sake rather than a

protection for the consumer or an encouragement to international trade. This of course ignores entirely the differences in dietary habits throughout the world and the importance of variety in food.

Efforts towards international standards can be traced back to a recognition of their advantages at the beginning of this country. Pure food congresses were held in Geneva in 1908 and in Paris in 1909, but the tide of world events culminating in the 1914-1918 war swept away such ideals. These ideals were not to reappear on the international scene for a whole generation, during which time the world was once more the scene of catastrophic destruction during the war of 1939 to 1945.

Since that time, events have gathered pace, encouraged in the first instance by the setting up of the Food and Agriculture Organization of the United Nations (FAO) with food problems as one of its areas of primary concern. At about the same time, the World Health Organization (WHO) commenced a certain amount of work on food additives and food hygiene.

In 1958 however two events took place which led directly to the Codex Alimentarius as it is known at the present time. Firstly, FAO set up the Committee on the Code of Principles for Milk and Milk Products, and secondly the International Commission on Agricultural Industries and the International Bureau of Analytical Chemistry jointly set up the Codex Alimentarius Europaeu. The first named Committee first drew up a code of conduct, and passed on to the work of developing standards for the main dairy products. Their method, adopted empirically, since they are somewhat more free from procedural rule than Codex itself, of sending draft standards to governments for comment, and finally for acceptance, has by and large been adopted by the Codex Alimentarius for its wider work. The most important thing demonstrated by this Committee however is that international standards can be agreed and when agreed, would be accepted by many countries.

The inspiration for the second precursor to Codex, the Codex Alimentarius Europaeu came largely from the late Dr. Frenzel, a former Austrian Minister, who thought that the system of the Codex Alimentarius Austriacus could be adapted to the whole of Europe and perhaps, ultimately, to the whole world. The idea was still-born, largely due to the fact that it was not clear what status the Codex would have in law when it was formulated, and since it was inadequately financed. It did complete, however, a generalized text on principles and sampling, and a standard for edible fungi. At their annual meeting in June 1961, the Council of the European Codex Alimentarius passed a resolution suggesting that the work should be embraced by FAO and WHO.

This resolution provided just the catalyst needed to assist a group of people, led by Francis Townshend of FAO who had been advocating for some years a truly international effort in this field. In November 1961 the FAO conference passed a resolution to set up the Codex Alimentarius Commission, which was ratified by the Executive Board of WHO in January 1962, and the inaugural conference was held in Geneva in October 1962.

The whole theme of Codex Alimentarius has been formulated as follows: 'The Codex standards aim at protecting consumers' health and ensuring fair practices in the food trade. Their publication is intended to guide and promote the elaboration and establishment of definitions and requirements for foods, to assist in their harmonization, and in so doing to facilitate international trade'. Two things stand out very clearly in favour of the Codex Commission: it has never underestimated the importance of a clear procedure, and it decentralised its' work to provide for progress on a broad front. Many previous attempts at meaningful international food standards have come to grief due to the lack of a proper procedure.

The Codex's unique committee system ensures that the full Commissions' discussions are not too frequently bedevilled by detailed work. The committees are of two main types. Commodity committees deal, as their name suggests with the main groups of foodstuffs, whilst other committees cover general topics such as general principles, hygiene, labelling, additives, pesticide residues and methods of analysis and sampling. The responsibility for running each committee and for piloting standards through the various stages of elaboration is taken by member governments.

It is unique in international collaboration in the field of food standards that Codex has a clearly defined and, thus far, successful procedure for the elaboration of standards. The responsible commodity Committee draws up and considers a draft standard. This draft standard is then twice circulated for government comments, again examined by the Committee in the light of these comments, and then considered by the Commission before circulation for final acceptance by governments. Although this procedure seems, and indeed is, lengthy, it does ensure that ample consideration is given to the aims and scope of the various standards, that governments examine the standards in detail and appreciate all aspects of them whilst still in draft form. As many different new points as possible are also assimilated by this method.

It perhaps should be said here that it is usual in member countries for a particular government department to undertake the responsibility for the government comments on Codex standards. In the United Kingdom, the Food Standards Division of the Ministry of Agriculture, Fisheries and Food speaks for the trade and the government in Codex, which has the advantage that those responsible for national legislation also deal with the comparable international aspects. In the UK the views of the food industry and other interested parties on the need, form and content of various standards are obtained by the Ministry through a National Codex Committee and various Commodity sub-committees.

The format of any Codex standard shows that the product is defined, essential composition and quality factors are laid down and permissible treatments, additives, levels of contaminants and methods of analysis are specified. The product is also given a statutory name and any appropriate special labelling rules. Clearly, Codex does not, in the elaboration of commodity standards, try to synthesise existing national

legislation, nor does it lay down exhaustive standards and rigid recipes. The stress is always on the substantive principles of the standard and the acceptance procedure provides for Governments to accept standards *"in toto"* or with some minor reservations to take account of national and constitutional procedures.

Fruit standards, which are of great interest to the delegates to this Conference are the concern of three bodies within the framework of Codex. The Codex Committee on Processed Fruits and Vegetables, for which the United States of America is the host Government has the following terms of reference: 'To elaborate world wide standards for all types of processed fruits and vegetables including dried products, canned dried peas and beans, jams and jellies, but not dried prunes or fruit and vegetable juices'. The United Nations Economic Commission for Europe jointly with the Codex Alimentarius Commission have set up two groups of experts. One, the Group on Standardization of Quick (Deep) Frozen Foods deals with those fruits which are processed for sale in this manner, in accordance with the General Principles of the Codex Alimentarius in addition to the elaboration of standards for other quick (deep) frozen foods not specifically alloted to another Codex Committee. The Group on Standardization of fruit juices the title of which is self-explanatory functions in the same way. Outside the Codex, the ECE Working Party on Perishable Foodstuffs is concerned with fresh fruit, and reports to the Codex Commission on its deliberations.

This is not the place to discuss the detail involved in international fruit standards but Appendix I to this paper gives details of specific commodities under consideration. For completeness, details of non-fruit commodities which are the concern of these bodies are included.

In addition to the Commodity Committees there are six world wide general subject committees of the Codex Alimentarius Commission, each of which influence the work devoted to specific groups of foodstuffs. These bodies are as follows:

1) The Codex Committee on Food Additives, whose responsibilities are 'to endorse or establish permitted levels of use for individual food additives and maximum permitted levels for contaminants in specific food items'. This Committee also submits lists of food-additives for toxicological evaluation by the Joint FAO/WHO Expert Committee on Food Additives.
2) The Codex Committee on Food Hygiene who are responsible for drafting basic provisions on food hygiene applicable to all food and to provide or endorse provisions on hygiene require y Commodity Committees for particular foods.
3) The Codex Committee on Food Labelling whose responsibilities are 'to draft provisions on labelling applicable to all foods and to endorse specific labelling provisions prepared by Commodity Committees drafting commodity standards.
4) The Codex Committee on General Principles deals with procedural and general matters referred to it by the Codex Alimentarius Commission such as defining the purpose and scope of Codex, the nature of Codex standards and the forms of acceptance by governments of standards.
5) The Codex Committee on Methods of Analysis and Sampling is responsible for specifying standard methods of analysis applicable to foods in general, the consideration, amendment if necessary and endorsement of methods proposed by Commodity Committees and the development and revision of such methods as required.
6) The Codex Committee on Pesticide residues proposes international tolerances for pesticide residues in specific foods and establishes priorities for toxicological evaluation by the WHO Expert Committee on Pesticide Residues for those residues found in food commodities entering international trade.

Appendix II to this paper comprises a Table illustrating the structure of the Codex Alimentarius Commission and its various committees.

We have tried to give a glimpse of the enormous amount of work by many countries which has gone into the establishment of Codex Alimentarius thus far. Nevertheless, the real test of the exercise, when all the work is complete will inevitably be as and when the various standards come up for acceptance by Governments. If all that Governments are prepared to do is to compare the standards with their own legislation and accept the ones that are exactly the same, we shall all have been wasting our time. Clearly, only if the standards can be accepted by the majority without major reservations and incorporated into the national legislation will the effort have been worthwhile, and world wide standards with some meaning have been evolved.

One cannot therefore forecast at this juncture whether Codex will work or not. We can however bear in mind the different opinions that exist throughout the world concerning the aims of Codex. In the United Kingdom Codex is regarded as an exercise in the harmonization of food legislation. Some countries believe that Codex standards would define products in commercial contracts whilst others see Codex as a reference volume of food identities, giving an indication of fair trading practices which could be quoted in law, but which would have no effect on national legislation.

The majority view seems to be that of the UK, that the effort is designed to harmonize food legislation. One hopes that many developing countries will accept Codex standards *in toto*. Naturally they are reluctant to base their food law simply on the existing laws of developed countries whose problem are markedly different from their own. If they feel a fresh start is for them, then the obvious choice is now the Codex Alimentarius, and even if the time is not ripe for their own national legislations, imports may be based, even on a simple contractual basis on Codex standards.

We could perhaps end by quoting some remarks (Davies, 1968), this year's Chairman of the Codex Alimentarius Commission. 'The Codex Alimentarius is a hopeful try, in a field where considerable benefits exist for everyone. To reap these benefits we will all need patience, consideration and respect for the customs and views of

others, together with a will to overcome inevitable difficulties. If we succeed we shall have achieved something of great benefit for all the people of the world, and will have done almost no harm to anyone. There are not many other, human activities about which this can be said'.

Reference

Davies, J. H. V. *Chemistry and Industry*, (1968), 337.

1 Codex Committee on Processed Fruits and Vegetables

a *Standards to be sent out shortly to Governments for acceptance*

Canned tomatoes
Canned green beans and wax beans
Canned peaches
Canned apple sauce
Canned grapefruit
Canned sweet corn

b *Standards to be before the Commission at its next meeting at the final stage of the Procedure*

Canned pineapple

c *Standards still under consideration*

Canned green garden peas
Canned mushrooms
Canned strawberries
Canned plums
Canned raspberries
Canned fruit cocktail
Canned pears
Canned mandarin oranges
Canned asparagus
Processed tomato concentrate
Raisins
Table olives
Jams and preserves
Canned beans in tomato sauce
Canned processed peas
Canned carrots
Canned fruit salad (other than tropical)
Canned tropical fruit salad
Canned two fruit salad
Dried figs
Cucumber pickles

2 Joint ECE/Codex group of experts on quick-frozen foods

Quick-frozen strawberries
Quick-frozen peas
Quick-frozen raspberries
Quick-frozen spinach
Quick-frozen bilberries
Quick-frozen blueberries
Quick-frozen broccoli
Quick-frozen brussels sprouts
Quick-frozen cauliflowers
Quick-frozen green beans
Quick-frozen peaches
Quick-frozen sour cherries

3 Joint ECE/Codex group of experts on standardization of fruit juices

a *Apricot, peach and pear*

Single-strength juices, ready for consumption, preserved exclusively by physical means:

Apple
Orange
Grape
Tomato
Lemon
Grapefruit
Pineapple

Concentrated juices, ready for consumption after dilution, preserved exclusively by physical means:

Apple
Orange
Grape
Tomato

b *Standards on which work has not yet begun, but in the future work programme*

Nectars	*Fruit Juices (Preserved by physical means)*
Blackcurrant	Bilberry
Raspberry	Blackcurrant
Bilberry	Cranberry
Passion fruit	Lime
Red currant	Tomato juice cocktail
Cranberry	Citrus reticulata and hybrids
Cloud berry	
Paw-paw	
Strawberry	
Whortleberry	
Rowan berry	
Guava	

Fruit juices beverage with a high juice content

There are neither nectars nor soft drinks: types not specified but to be drafted by Spain.

4 Working party on standardization of perishable foodstuffs of the Economic Commission for Europe's Committee of Agricultural Problems

Food Standards Works

a *Products for which European standards exist*

Apples (1)	Shelling peas
Pears (1)	Beans
Tomatoes	Carrots
Cauliflowers	Citrus fruit (mandarins, clementines, satsumas, lemons, wilkings, oranges and grapefruit)
Onions	Seed potatoes
Lettuces curled-leaved	Asparagus
Endives and broad-leaved (batavian) endives	Watermelons
Peaches	Cucumbers
Apricots	Cabbages
Plums	Wood bilberries
Early potatoes	Brussels sprouts
Artichokes	Ribbed celery
Cherries	Horse-radish
Strawberries	
Witloof chicory	

Spinach
Table grapes

Garlic
Scorzonera
Ware potatoes
Unshelled sweet almonds

b *Products for which recommendations exist* (2)

Peppers
Hazel nuts in shell
Decorticated hazel nuts
Walnuts in shell
Walnut kernels

Sweet almonds in shell
Dried prunes
Cultivated mushrooms
Raspberries
Leeks

c *Products for which standards are in the course of being prepared*

Decorticated sweet almonds
Fennels

Dried figs
Dried apricots
Dates

Aubergines
Melons
Pistachios

Fruit pulps
Fruit juices (3)
Quick-frozen foods (3)

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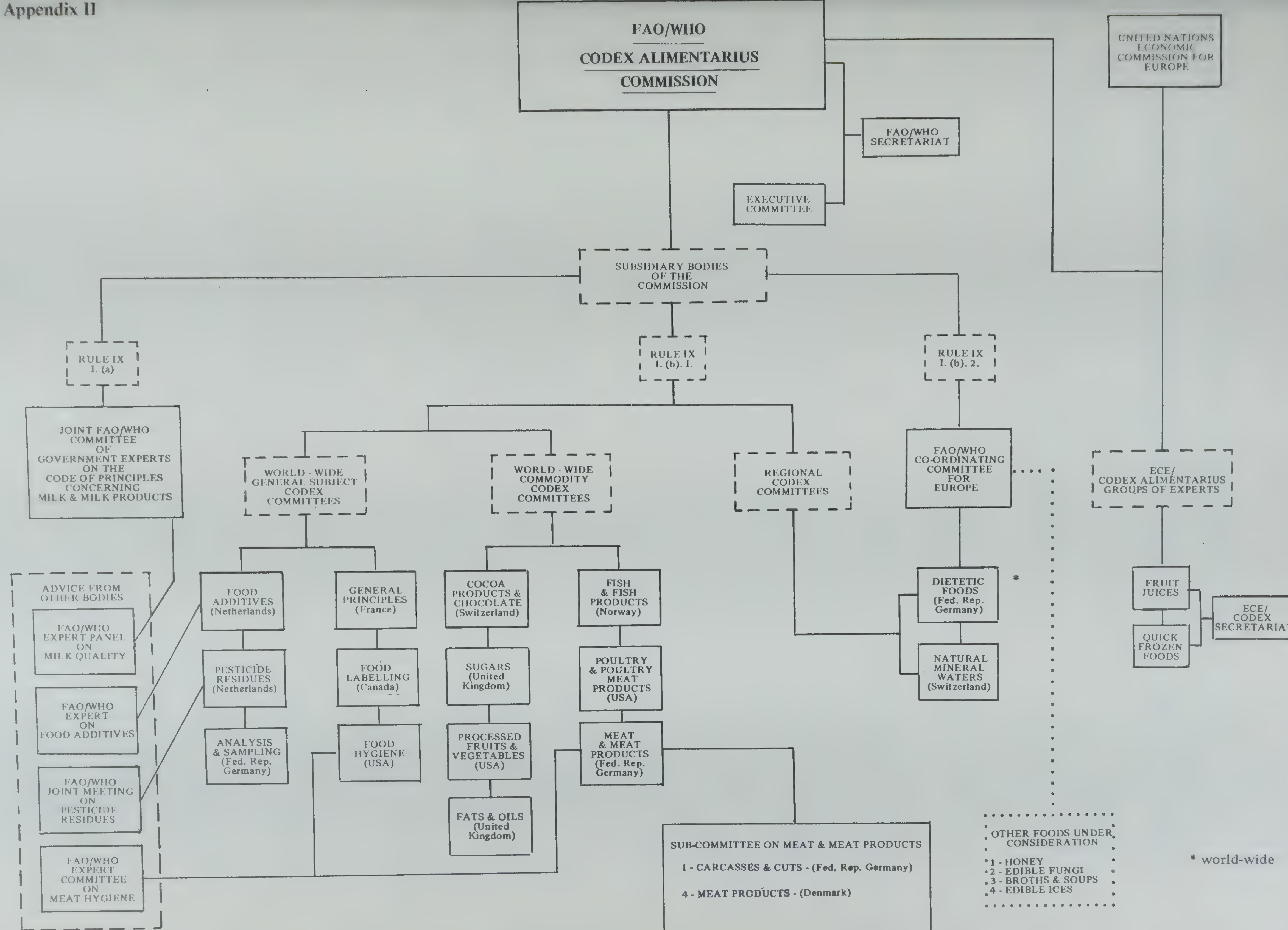
(1) The Working Party is reviewing and has revised the European Standard for Apples and Pears with a view to making its field of application wider.

(2) If the text of a proposed standard requires a little further examination before it can be adopted as a European Standard e.g. if some of its provisions need to be tested in practice, it is sometimes issued as a recommendation of the Working Party for a limited period. As a result of this further examination, the text with whatever consequent alterations that may be decided upon, is then normally adopted as a European Standard.

(3) Standards for these products are being elaborated jointly with the Codex Alimentarius Commission. (References ALINORM 69/14 and ALINORM 69/25).

Appendix II



FAO/WHO CODEX ALIMENTARIUS COMMISSION
UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE
FAO/WHO SECRETARIAT
EXECUTIVE COMMITTEE
SUBSIDIARY BODIES OF THE COMMISSION
RULE IX I. (a)
RULE IX I. (b). 1.
RULE IX I. (b). 2.
JOINT FAO/WHO COMMITTEE OF GOVERNMENT EXPERTS ON THE CODE OF PRINCIPLES CONCERNING MILK & MILK PRODUCTS
WORLD - WIDE GENERAL SUBJECT CODEX COMMITTEES
WORLD - WIDE COMMODITY CODEX COMMITTEES
REGIONAL CODEX COMMITTEES
FAO/WHO CO-ORDINATING COMMITTEE FOR EUROPE
ECE/ CODEX ALIMENTARIUS GROUPS OF EXPERTS
ADVICE FROM OTHER BODIES
FAO/WHO EXPERT PANEL ON MILK QUALITY
FAO/WHO EXPERT ON FOOD ADDITIVES
FAO/WHO JOINT MEETING ON PESTICIDE RESIDUES
FAO/WHO EXPERT COMMITTEE ON MEAT HYGIENE
FOOD ADDITIVES (Netherlands)
PESTICIDE RESIDUES (Netherlands)
ANALYSIS & SAMPLING (Fed. Rep. Germany)
GENERAL PRINCIPLES (France)
FOOD LABELLING (Canada)
FOOD HYGIENE (USA)
COCOA PRODUCTS & CHOCOLATE (Switzerland)
SUGARS (United Kingdom)
PROCESSED FRUITS & VEGETABLES (USA)
FATS & OILS (United Kingdom)
FISH & FISH PRODUCTS (Norway)
POULTRY & POULTRY MEAT PRODUCTS (USA)
MEAT & MEAT PRODUCTS (Fed. Rep. Germany)
SUB-COMMITTEE ON MEAT & MEAT PRODUCTS
1 - CARCASSES & CUTS - (Fed. Rep. Germany)
4 - MEAT PRODUCTS - (Denmark)
DIETETIC FOODS (Fed. Rep. Germany)
*
NATURAL MINERAL WATERS (Switzerland)
OTHER FOODS UNDER CONSIDERATION
1 - HONEY
2 - EDIBLE FUNGI
3 - BROTHS & SOUPS
4 - EDIBLE ICES
FRUIT JUICES
QUICK FROZEN FOODS
ECE/ CODEX SECRETARIAT
* world-wide

Fruit standards: The viewpoint of the International Organization for Standardization

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Summary

Standardization in its general sense covers the formulation of accepted reference criteria which are aimed at facilitating transactions of various kinds. Standards are not limited to specifications but concern terminology, classifications, methods of test, etc. and the scope of a standards organization can also include publications on accepted good practice. Most developed and developing countries have organizations for the preparation of national standards, but standards developed on a purely national basis can differ sufficiently from one country to another to become barriers to international trade.

The primary aim of the International Organization for Standardization (ISO) is the harmonization of national standards which are important for international trade. Standards used purely nationally are not the concern of ISO. It operates through technical committees, the member bodies of which are the national standards organizations of interested countries, and these committees develop 'ISO Recommendations' which serve as agreed bases for national standards.

Agricultural food products are the concern of Technical Committee 34, which has a sub-committee (SC 3) dealing with fruits, vegetables and their derived products in general. Hitherto, work specifically relevant to tropical and subtropical fruits has consisted mainly in the preparation of documents giving guidance on the best conditions for successful storage. Apricots, avocados, citrus fruits, green bananas, peaches and pineapples have received or are receiving attention. For green bananas and pineapples the emphasis is on keeping during transport.

Recently, work has begun on the development of ISO Recommendations relating to nuts, nut kernels, dried fruits and dehydrated fruits. It is envisaged that specifications will be included, as well as any aspects of the subject not already being studied within SC 3.

Liaison exists between ISO/TC 34 and other interested international bodies such as the Codex Alimentarius Commission and ECE Committees to avoid duplication of work.

Introduction: standardization, national and international

The term *standardization* is used in various ways, but in the context of the present paper it means the *preparation of standards,* i.e., of accepted reference criteria. Standards are not limited to specifications; terminology, classifications, methods of test and units of measurement, for example, also constitute subject matter for standards. The aim of standardization is to facilitate transactions of various kinds, by providing ready-made, authoritative documents to which reference can be made. Standards provide a common language, and thereby reduce ambiguities or misunderstandings.

Because of the value of standards in commerce, industry and technology, most of the developed and developing nations have set up organizations for the preparation of *national standards.* By being published in a national series, standards have a broader basis and gain a wider acceptance than if they were prepared by the interested industries or specialist organizations themselves. The United Kingdom was the pioneer in this field, and the British Standards Institution is the lineal descendent of a small body that was set up in 1901 but at first dealt only with engineering specifications. British Standards are prepared on a purely voluntary basis by representatives of producers, users and other interested bodies; they have no mandatory force unless they are cited in legislation. Besides standards in the strict sense, BSI publishes 'Codes of Practice' and similar guidance documents which provide a consensus of expert opinion on good practice in various fields of activity. The standards organizations of many other countries have been modelled on BSI and work in a similar way.

While national standards facilitate trade within a particular country, they can constitute barriers to *international* trade. This situation arises when corresponding standards in different countries present marked differences and make it necessary to work to different criteria, or to use different methods of test for compliance with the criteria, according to whether a product is destined for home trade or for export. The elimination of barriers of this kind is the primary purpose of the *International Organization for Standardization* (ISO), which aims at the harmonization of national standards by providing common, agreed bases for them. The publications of the ISO take the

form of 'ISO Recommendations', each of which provides a prototype for national standards having a particular scope. Thus, national standards which individually agree in content with an ISO Recommendation are, *ipso facto,* in harmony with one another.

The member bodies of the ISO are the national standards organizations of over 50 developed and developing countries, and its scope is the whole field of industry and technology excluding electrotechnics, which is the concern of a sister organization. ISO Recommendations are prepared by technical committees, now numbering over 130, in which member bodies interested in the particular subjects take part. There is no compulsion to adopt an ISO Recommendation, but member bodies which have assisted in its development normally implement it in a national standard, either by preparing a new standard or by modifying an existing one. As indicated, the concern of ISO is with standardization which is important for international trade; it is not interested in standards that are used purely nationally. Like national standards, ISO Recommendations take many forms: specifications, vocabularies, classifications, methods of test, etc., or guides to accepted good practice.

ISO work relevant to tropical and subtropical fruits

ISO Technical Committee 34, 'Agricultural Food Products', is the parent body of eight sub-committees which deal with particular groups of commodities within the very wide scope of this subject. Of these, the sub-committee of immediate interest is SC 3 -'Fruits, Vegetables and their Derived Products'. The Secretariat of this sub-committee is held by Poland (i.e. by the Polish standards organization), and the membership covers 30 countries, of which 19 have Participating ('P') Member status and the others rank as Observer ('O') Members. The United Kingdom, through BSI, has 'P' Member status in this sub-committee, as in ISO/TC 34 itself and the other sub-committees. Among member bodies which may be expected to have a particular interest in tropical and subtropical fruits are Australia, India, Iran, Israel, South Africa, Turkey and USA, but hitherto France has been the most active in initiating work relating to such fruits.

The broad terms of reference for the sub-committees were agreed at the outset by ISO/TC 34 itself, and represent the views of that committee on the useful scope for international standardization with regard to agricultural food products in general. The topics envisaged are: (1) terminology, (2) methods of sampling and testing, (3) packaging, (4) storage, handling and transport. No firm guidance was given by ISO/TC 34 on whether or not specifications of quality should be prepared, as it was realized that the need for general specifications for trade purposes, and indeed the difficulties of preparing them, would vary considerably according to the commodities and trade practices concerned. Each sub-committee, therefore, has been left to decide for itself whether or not to prepare quality specifications.

As its title indicates, Sub-Committee 3 is concerned with fruits and vegetables in general, both in the fresh state and in the form of processed products. The detailed work required for preparing Draft ISO Recommendations has been delegated to *working groups,* and until recently the allocation was based quite simply on the original terms of reference. Thus, individual working groups deal with: (a) terminology, (b) sampling, (c) methods of test, (d) storage and transport. A working group on packaging was originally envisaged, but more recently it has been decided to deal only with such aspects as are important for storage and transport, and as such the work has been included under (d). In 1966, on the initiative of Iran, it was agreed to establish a further working group to deal with 'dry and dried fruits' (i.e. nuts, nut kernels, dried fruits and dehydrated fruits). This is the only working group which is specifically related to particular products within the field of SC 3.

A brief account may now be given of the work done, or in progress, by the individual working groups. The terminology working group has two projects in hand: (1) botanical nomenclature of fruits and vegetables, based on internationally accepted Latin names and giving the corresponding common names in the official ISO languages (English, French and Russian), (2) nomenclature of structural parts. These projects are being developed in stages. The first parts of the botanical nomenclature, limited to fruits and vegetables for which the Latin names are not in dispute, will shortly be issued as Draft ISO Recommendations*; this is true also for the first series of designations, in the ISO languages, of the structural parts of various fruits and vegetables.

The working group on sampling has prepared a method of sampling fresh fruits and vegetables, which is primarily intended for use in case of dispute between contracting parties. This has now been published as an ISO Recommendation, and the group is currently engaged on the sampling of canned and bottled products. Methods of test are at present being developed (by the relevant group) only for processed products. Several have already been published as ISO Recommendations (determination of titratable acidity, water-insoluble solids, mineral impurities, ash insoluble in hydrochloric acid, total solids) and others are at earlier stages of development. None of these methods relates specifically to particular fruits or vegetables, other than a method for the determination of essential oil in citrus fruit juices or bases for soft drinks. This will shortly appear as a Draft ISO Recommendation.

The usual method of procedure in the working groups concerned with methods of test and with storage and transport is for a member country which has a special interest or expertise to act as 'rapporteur' for a particular project. The rapporteur produces the first draft on that project and may also be responsible for subsequent drafts, incorporating modifications agreed in discussions by the working group, until the document passes beyond the working group stage. The documents produced by the working group on storage and transport give

* A Draft ISO Recommendation is a document which, having been developed by, or under the aegis of, an ISO technical committee, is circulated to all the ISO Member Bodies for approval.

guidance on the best conditions for obtaining a useful storage life, with or without refrigeration as the case may be, in static storage or during transport. Of necessity they are in general terms only, because of the variations that may be necessary to take account of different cultivars, ecological factors, etc. The general pattern of the documents include sections on conditions of harvesting and putting into storage (varieties, criteria of ripeness, quality characteristics for storage etc.), optimum conditions for storage (temperature, relative humidity, air circulation, etc.), and adjuncts or other keeping processes.

No mention need be made here of the storage of vegetables or of many of the fruits considered by this working group, but the following projects are of interest. (The country acting as rapporteur is shown in parenthesis.)

Cold storage of peaches (France)
Storage and transport of green bananas (France)
Storage and transport of fresh pineapples (France)
Cold storage of apricots (Hungary)
Storage and transport of avocados (France)
Storage of citrus fruit (Israel)

The first two projects have been completed by the publication of ISO Recommendations, and the third is at the Draft ISO Recommendation stage; the others are at earlier stages of development.

As already mentioned, the working group on dry and dried fruits differs from the others in being concerned with a defined group of products rather than with particular aspects of a wide range of products. In practice it has been agreed that the sampling of dry and dried fruits, and test methods which are not specific to these products (e.g. the determination of sulphur dioxide), should be the concern of the working groups which are already dealing with these facets of SC 3 work. The new working group has proposed definitions of 'dry fruits' and 'dried fruits' and has embarked on the preparation of a list of products belonging to these categories. It is also envisaging the preparation of specifications for products which are not already engaging the attention of other international bodies, cashew nuts and groundnuts being proposed initially.

Liaison with other international organizations

At this point, mention should be made of the relations between the ISO and other international bodies dealing with particular aspects of standardization. It is a general principle of the ISO that, in the development of ISO Recommendations, account will be taken not only of existing national standards but of any related activity by other international organizations, some of which have limited fields of interest impinging on the scope of particular ISO committees. Duplication of effort is avoided as far as possible, sometimes by the adoption, if necessary with modifications, of specifications or methods prepared by other international organizations, and sometimes by agreement on the distribution of work.

ISO/TC 34 itself has established liaison with four other ISO technical committees and some 40 other international bodies, and in the particular field of SC 3 there is liaison between the sub-committee and the following organizations:

International Bureau for Plant Taxonomy and Nomenclature
International Institute of Refrigeration
International Wine Office
Economic Commission for Europe (ECE)
– Committee on Agricultural Problems
– Working Party on Standardization of Perishable Foodstuffs
Joint FAO/WHO Codex Alimentarius Commission
– Codex Committee on Methods of Analysis and Sampling
– Codex Committee on Processed Fruits and Vegetables
Joint ECE/Codex Group of Experts on Standardization of Quick Frozen Foods.

Close co-ordination is particularly necessary with regard to specifications for dry and dried fruits. The ECE Working Party on the Standardization of Perishable Foodstuffs has been working for some time on specifications for various nuts, and the Codex Committee on Processed Fruits and Vegetables has been developing specifications for processed raisins and dried currants. Recently, both these organizations have circulated draft standards for pistachios, dates, dried apricots and dried figs. Clearly, an agreed division of the field between ISO, ECE and Codex is highly desirable if wasteful duplication of effort is to be avoided.

The ISO ranks as a non-governmental organization, although the relationship of national standards organizations to their own governments varies from country to country. On the other hand, the members of the ECE and the Codex Alimentarius Commission are national governments. The aim of the Codex Alimentarius Commission is a unified system of food standards for embodiment in the national legislation of the member countries, to ensure fair trading and the protection of the consumer. Such harmonization will also help international trade and, as commercial contracts, specifications or other agreements based on ISO Recommendations must take account of legal requirements, there is a clear need for liaison between ISO and Codex activities in this field. This liaison, which already exists at various levels, is of benefit to both sides since work already done, or in progress, by ISO can lighten the task of the Commission.

Conclusion

The main points of this paper may be summarized as follows:

i The primary purpose of the ISO is to facilitate international trade by the harmonization of corresponding national standards, and this is done through the preparation and publication of 'ISO Recommendations' which serve as prototypes for national standards.

ii The preparation of ISO Recommendations relevant to tropical and subtropical fruits falls within the framework of Sub-Committee 3 of ISO Technical Committee 34 – Agricultural Food Products.

iii The aspects of standardization with which ISO/TC 34/SC 3 is concerned are: terminology, sampling, methods of test, storage and transport, and (as appropriate) specifications.

iv In the preparation of ISO Recommendations, account is taken of relevant work by other international organizations.

Appendix

ISO Recommendations and Draft ISO Recommendations of interest in the context of Tropical and Subtropical Fruits

Published ISO Recommendations

R 750	Fruit and vegetable products -determination of titratable acidity
R 751	Fruit and vegetable products -determination of water-insoluble solids
R 762	Fruit and vegetable products -determination of mineral impurities
R 763	Fruit and vegetable products -determination of ash insoluble in hydrochloric acid
R 873	Peaches – guide to cold storage
R 874	Fresh fruits and vegetables – sampling
R 931	Green bananas – guide to storage and transport
R 1026	Fruit and vegetable products – determination of total solids.

Draft ISO Recommendations

DR 1838	Fresh pineapples – guide to storage and transport
DR 1842	Fruit and vegetable products – determination of pH.

Maintaining market quality of Florida avocados

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and

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Summary

Market quality of avocados is maintained by a sequence of procedures beginning with the selection of improved varieties and proper production practices and progressing through the storage, transportation, and marketing of the fruit.

In Florida, the avocado harvesting and marketing season usually begins in June and ends in February. Maturity standards have been established for each variety and must be met as specified in a Federal Marketing Agreement. The standards are based on either minimum fruit weights or diameters which must be attained on designated shipping dates.

The optimum storage condition for 'Booth 1', 'Booth 8', 'Lula', and 'Taylor' avocados, which are cold-tolerant varieties, is 4.4°C., for approximately a month. The optimum storage condition for West Indian varieties such as 'Fuchs', 'Pollock', and 'Waldin' is 12.8°C for 2 weeks. The optimum ripening temperature for Florida avocados is 15.6°C.

Recent findings indicate that 'Lula' avocados can be stored successfully for 60 days in a controlled atmosphere (CA) of 1% 0_2 + 9% CO_2 at 10°C.

Introduction

The avocado (*Persea americana* Mill.), which originated in tropical America, is becoming increasingly popular with consumers in the temperate zones. This increasing popularity is indicated by the increased production of avocados in the United States. During the period from 1929 through 1961, the production increased at a rate of 10.2% a year (Markeson, 1963). The extensive development of rapid modern transportation and refrigeration facilities has enabled the industry to move high quality produce from the grove to the consumer.

The avocado is grown throughout the tropical and subtropical world, most often as seedling and dooryard trees in Central America, Mexico, and the West Indies. The largest commercial plantings of grafted trees of named varieties are found in Israel, South Africa, and the United States, especially in peninsular Florida and southern California. Excluding citrus, the avocado ranks third after the banana and the pineapple in export trade (non-local consumption) of tropical fruits (Ochse, *et al,* 1961).

For centuries the avocado, which possesses high nutritional value, has been a basic food crop in its indigenous area; however, commercial production in the United States did not begin until about the turn of the century. In 1967, about 12,700 metric tons of avocados were shipped from Florida; this represented over 2,000 hectares of commercial plantings. For the same year, the combined production from Florida and California was reported as 48,263 metric tons, having a value in excess of 22 million dollars (US Dept of Agr., 1968).

Selection of commercial varieties

Some of the factors to be considered when avocado varieties are chosen for planting are size, colour, and time of maturity of the fruit.

In 1920 Popenoe classified avocados into the West Indian, Guatemalan, and Mexican races. Recently the classification has been less distinct because of the increasing number of hybrid varieties and the discovery of intermediate types (Popenoe and Williams, 1947, Schroeder, 1947).

West Indian avocados are intolerant to cold and thus are confined largely to the tropical lowlands. In the continental United States, West Indian varieties are grown commercially only in southern Florida. The fruit matures during the summer and fall and has a relatively low oil content. 'Waldin' is the leading variety, followed by 'Pollock'. Guatemalan, and especially Mexican races, are higher in oil and are more tolerant to cold than the West Indian. Most commercial varieties in Florida are West Indian x Guatemalan hybrids of unknown parentage. Some are almost as intolerant to cold as West Indian varieties, while others are about as tolerant to cold as Guatemalan varieties. These hybrid varieties mature during the fall and winter. 'Lula' and 'Booth 8' are important hybrid varieties which account for over 50% of the Florida crop.

The relatively unimportant Guatemalan varieties mature during the fall and reach a peak during the winter. 'Taylor' is the most important Guatemalan variety produced in Florida.

Because of different climatic conditions, avocado varieties grown in Florida differ from those grown in California. Florida has a climate typified by warm, humid summers and mild, dry winters, while California has a typically Mediterranean-type climate, with dry summers and cool, humid winters. As a result of these differences, Guatemalan and hybrid varieties of Guatemalan x Mexican, which are much hardier against cold weather than Florida varieties, are grown in California. Varieties adapted to California are susceptible to fruit decay under the warm, humid Florida conditions.

Avocados adapted to Florida conditions are retained on the tree for only 1 to 3 months after full maturity. A single variety capable of bearing for extended periods has not been developed for Florida. Consequently numerous varieties which mature progressively from June through February have been adopted. Avocados adapted to California conditions are retained on the tree considerably longer after full maturity than those grown in Florida. The 'Fuerte' avocado, which accounts for over 50% of the California crop, is harvested from October to June.

Ruehle (1963) published a comprehensive bulletin which included recommended spray, fertilization, irrigation, and pruning programmes for avocado growing in Florida. These programmes are essential production practices which directly affect the quality of the fruit.

Maturity standards

To assure that only high quality avocados are marketed and to sustain industry esteem, maturity standards for this fruit are enforced in the United States.

In Florida, a Federal Marketing Agreement specifies separate maturity standards for each variety. The standards are based on either minimum fruit weights or diameters which must be attained at designated shipping dates (US Agricultural Marketing Service, 1954). For most varieties, the specifications permit the larger sizes of fruit to be shipped on initial shipping dates; and as the season progresses, restrictions as to fruit size are gradually lowered and eventually removed. Fruit weight and diameter can be used interchangeably for purposes of harvesting or for sizing at the packing house (Hatton *et al*, 1963).

In contrast to Florida, California uses oil content to rate avocado maturity, and a State regulation specifies a minimum of 8% oil for all varieties (California Bureau of Fruit and Vegetable Standardization, 1947). Increases in oil content of avocados as the crop year advances have long been recognized by various workers (Church and Chace, 1922; Stahl, 1933a, b; Haas, 1937).

The oil content of Florida avocados is low because West Indian and West Indian x Guatemalan hybrids predominate. Conversely, oil content of California avocados is relatively high due to prominence of Guatemalan and Mexican x Guatemalan hybrids.

Palatability generally increases rapidly as fruit matures and is closely related to increases in fruit weight and oil content (Hatton *et al*, 1964). Considering the many commercial varieties and types of avocados in Florida, the present method of determining maturity appears satisfactory. It is a simple non-destructive method which does not require tedious laboratory procedure.

Grading and packing

Florida avocados are graded by hand at the packing house and then sized by automatic sizers or weight devices. Inspection grades under the Marketing Agreement are based on (1) similar varietal characteristics, (2) maturity, (3) normal shape, (4) trimming of the stem, (5) normal colour, (6) firmness, (7) defects, and (8) decay. The most common defects which may reduce the grade of the fruit are *Cercospora* spot, scars, and avocado scab.

Adoption of the Marketing Agreement for Florida avocados has standardized the shipping containers. Fountain and Stokes (1958) evaluated eight different containers in actual test shipments, and thus helped promote the standardization of more satisfactory containers. Today Florida avocados are packed in (1) wooden or fibreboard flats that accommodate a single layer of fruit and net approximately 6 kg; (2) fibreboard cartons that accommodate two layers of fruit and net about 12 kg; and (3) fibreboard cartons that hold fruit weighing at least 0.5 kg each in several layers and net approximately 15 kg. Layers of excelsior are placed on the inside surfaces of the package as well as between the fruits.

Packed fruit is inspected by the Federal-State Inspection Service and must conform to maturity, grade, and pack regulations before it can be shipped to market.

Rapid and orderly shipping of Florida avocados is achieved by the use of refrigerated trucks which often haul several commodities in the same load. Temperatures in the trucks are usually set at approximately 10°C. Transit time is usually 1½ to 3 days to markets in the East Coast and 3½ to 5 days to markets in the West Coast. Hinds and Breakiron (1961) studied loading patterns in truck shipments of avocados and designed a pattern that greatly reduced load shifting, disarrangement,

container damage, and overheating and overripening of fruit in transit. Careful handling from harvest to the consumer is of utmost importance to avoid bruising of the fruit.

Conventional storage and ripening

Decay and chilling injury are the primary factors restricting the time avocados can be stored. The most prevalent decay observed in stored Florida avocados is anthracnose, *Colletotrichum gloeosporioides* Penz., which usually enters the fruit as a secondary infection after *Cercospora* spot or avocado scab. Prevention of *Cercospora* and avocado scab by timely spray applications is an important production practice that will reduce the amount of postharvest decay. Occasionally stem-end decay may be attributed to *Diplodia natalensis* Pole-Evans or to *Diaporthe citri* Wolf. For storage, the selection of fruit free of decay and blemishes is of utmost importance since no known postharvest treatments are available to prevent the spread of these decays in avocados.

The optimum storage condition for 'Booth 1', 'Booth 8', 'Lula', and 'Taylor' avocados, which are cold-tolerant varieties, is 4.4°C., for approximately a month (Hatton *et al*, 1965). The optimum storage condition for West Indian varieties such as 'Fuchs', 'Pollock', and 'Waldin' is 12.8°C for 2 weeks. Avocados may develop chilling injury if the optimum storage period is extended or the optimum storage temperature is lowered. However, cold-intolerant varieties can withstand 10°C for the usual domestic transit periods.

Chilling injury in avocados is characterized by several symptoms that may occur singly or in various combinations in different varieties. The most common symptom is a greyish-brown discolouration of the flesh, especially in the vascular tissue. The extent of discolouration may vary from almost inconspicuous trace areas in the flesh to severe cases where all the flesh is discoloured. Avocados which exhibit slight internal chilling injury symptoms do not show external injury. In severe cases, uneven ripening, development of undesirable flavours and odours, pitting, and a scald-like browning or darkening of the skin are common. Sometimes fruit may appear satisfactory while in storage but display chilling injury when allowed to soften at higher temperatures.

The optimum ripening temperature for Florida avocados is 15.6°C. For ripening and storage, a relative humidity of 85% to 90% should be maintained (Lutz and Hardenburg, 1968).

In commercial practice, avocados are sometimes stored up to a week at the packing houses prior to transit and then again at the terminal markets and retail outlets. When avocados are stored near the grove source, the shipper must plan carefully to move the fruit to the terminal market while the fruit is still firm so that it is not damaged and overripe when it arrives. Time spent in transit must be considered as storage time when planning the orderly handling of the produce.

Controlled-atmosphere storage

Limited success with CA storage of 'Lula' avocados was reported by Hatton and Reeder (1965). Unpublished findings in 1966 indicate that Lula avocados can be stored successfully for 60 days in an atmosphere of 1% O_2 + 9% CO_2 at 10°C. (Table 1).

Table 1

Acceptability of 'Lula' avocados after storage at 10°C. in controlled atmospheres and softened in air at 21.1°C Miami, Florida – 1966[1]

Storage atmosphere	Acceptable[2] fruit after 30 days	60 days	Appearance[3] of fruit after 30 days	60 days
Air	30a	0a	1.4a	1.0a
2% O_2 + 14% CO_2	100b	40b	3.1bcd	1.4a
3% O_2 + 14% CO_2	100b	0a	3.3b	1.0a
5% O_2 + 14% CO_2	80b	0a	2.5c	1.0a
1% O_2 + 9% CO_2	100b	100c	3.2bd	2.6b
5% O_2 + 10% CO_2	90b	0a	2.6cd	1.0a

1 Data were based on 120 avocados, 20 per atmosphere and 10 per storage period. For each storage period, data followed by different letters were significantly different at the 5% level; Multiple Range Test (Duncan, 1955).

2 Avocados which exhibited no severe external discolouration or decay. All acceptable fruit was palatable, and no internal discolouration was detected.

3 Based on extent of external discolouration: 4.0 = Excellent; 3.0 = good; 2.0 = fair; and 1.0 = poor. Avocados displaying decay were also rated poor. Fruits rated poor were considered unacceptable.

Tests are being continued at the US Department of Agriculture Laboratory at Miami, Florida, to compare the effects of storage in 1% O_2 + 9% CO_2 at 10°C. with those of other closely associated atmospheres and temperatures, and to compare the closed system, previously used, with a constant-flow system. A large-scale

test simulating commercial conditions is planned for the forthcoming season using 'Lula' avocados.

Successful CA storage of avocados could extend the market period and might expand the distribution of avocados to distant markets, especially if CA facilities were installed and utilized aboard ship.

Marketing

In Florida most of the avocado crop is marketed by growers and by handlers who grow their own fruit. Competition among independent handlers to sell fruit during periods of heavy supply tends to depress the price. The Florida avocado industry would benefit from an improved system of distributing and marketing (Manley and Godwin, 1960, Markeson, 1963). The crop is sold about equally on consignment and f. o. b. sales.

In Florida the large number of avocado varieties with different characteristics and sizes tends to suppress standardization, which is an important aspect in marketing, especially to the wholesaler, retailer, and consumer who are less familiar with varieties than the grower and shipper. In contrast to Florida, the California industry has a few important varieties and markets 60% of its crop through one sales agency.

In 1959 Brooke reported that the consuming public generally preferred small avocados but had no preference as to shape. Some special markets, however, accept or prefer large fruit (Trabucco, 1968). Fruits of some of the Florida commercial varieties are large. For example, the 'Pollock' often weighs more than 1.7 kg.

Since most of the commercial plantings have been devoted to green-skinned varieties, the consuming public is generally unfamiliar with red-, purple-, or black-skinned ones, although the eating quality can be equally as good as that of the green-skinned fruit. In Florida, the purple-skinned 'Hardee' and 'Linda' varieties are of minor importance. However, the small, black- and rough-skinned 'Haas' variety is gaining in popularity in California.

In conclusion, the market quality of avocados can be maintained by: (1) selection of improved varieties; (2) proper production practices; (3) adherence to maturity standards; (4) careful harvesting and handling operations; and (5) rapid and orderly shipping and marketing procedures with emphasis on recommended storage and ripening conditions throughout marketing channels.

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Discussion

Mr. Walker Is any consideration being given by the Codex Alimentarius Committee to the establishment of standards for dried fruit products?

Mr. Goodall The Codex Committee on processed fruit and vegetables has made a start on dried fruit products. A standard is at a fairly advanced state of preparation for raisins. It has also been circulating draft standards for dried figs and one or two other products. This Committee has concentrated on canned products so far, but is now moving in to the dried fruit field. There is some work going on in this field with ISO, and our intention is to ensure that this is incorporated into the Codex standards. The Economic Commission of Europe has done some work on some of the dried fruits and that also will be fed into the Codex machinery.

Dr. Tubbs Throughout the proceedings of this Conference, there has been a tendency to refer to tropical fruits by crop, not by variety within a crop. We have often spoken as though every mango was worth eating, or as though every durian stank: we all know that this is not the case. We also know that variety affects not only propagation and field culture but also fruiting season, commercial value, and optimum conditions for storage, transport canning, or preservation. Between varieties of a given fruit, there are all grades between potentially high yielders of valuable produce and relatively worthless varieties unworthy of any attention. Most commercial offerings of minor tropical fruits suffer from being unpredictable mixture of such variables, often of seedlings origin.

It is important, therefore, to note Dr. Sumner's reference to the co-operation of ISO with the International Commission for Plant Nomenclature. This in turn works closely with the International Society for Horticultural Science. As a result of the work of these organizations, comparisons and accurate descriptions of every important cultivar are being prepared in each co-operating country with a view to producing national lists for the identification of fruit cultivars, to be the basis for internationally agreed cultivar names and descriptions for every worthwhile clone.

Work has progressed further with the temperate fruits, including the foundation of the British National Fruit Trials at Brydale, Kent, the centre for apples and other fruits. The Fruit Section of the ISHS is pressing national governments to facilitate the printing of national lists and the completion of internationally agreed lists. The importance of reliable identification, because of quality, storage, and transport differences between the fruit of different varieties, cannot be overstressed if plantation, processing, and export industries are to become and remain viable. FAO is also very interested in such progress. The Commission for Tropical Horticulture of the ISHS, with its convener Dr. Tyndall of the National College of Agricultural Engineering, is the centre for international interest in such co-operation for tropical fruits.

Studies of cultivars must be long term for descriptions to be accurate for the fruit of mature trees. It is of great importance, therefore, that early attention be given to vegetative propagation of the best cultivars for commercial planting and, at the same time, to cultivar description. In too many cases different cultivars exist under a single and often incorrect name in different countries. The coming FAO Conference on vegetative propagation is therefore of the greatest importance to members of this Conference.

Dr. Fidler This of course is a very important point indeed. I have not had very much experience of the tropics or subtropics but such as I have has made me very despondent about the possibility of exporting fruit from the tropics. One would ask sometimes at a research station: 'What is the variety of this banana?' and be told: 'This is red banana'. There are so many varieties. There are so many cross-breeds and hybrids. Establishing varieties is essential to successful marketing.

Mr. Mulholland Regarding post-harvest disease control in citrus fruits and bananas, I do not know whether the same standards apply in Britain as in other European countries. We have recently had Thiabendazole cleared for use on these fruits by certain countries but not in others. Will Codex take over the clearing of these or will national standards still have to be kept?

Mr. Coomes The situation at the moment with regard to food preservatives in the UK is that they are controlled by the Preservatives in Food regulations. Control is at the point of sale. They must conform to these regulations. Diphenyl is permitted in certain citrus fruits. Thiabendazole and other sophisticated fungicides are not permitted. The possible use of some of these materials is currently being discussed.

One hopes that if the UK accepts Codex and its authority on food additives and food preservatives, national legislation will eventually conform with the international. However, one must bear in mind that agreements on food additives take some time. Common market countries have common legislation, and I hope we will find harmony with their legislation as well. But, if the inclusion of new additives is agreed, it will be 1971 before they are permitted.

Dr. Fidler Very often fungicides are not necessary if standards of harvesting and packing are high. Fungicides are frequently used only to cover bad practice.

Mr. Dalton In view of the continuing development of new food additives, insecticides and varieties of food, I wonder whether the work of Codex will ever be completed.

Mr. Coomes No, but as we see it at the moment, once the work of the major committees is complete, this will go out to Governments: this should be 3 to 4 years from now. One envisages the book will be published and the various committees will continue to meet fairly frequently on various aspects of Codex, particularly additives, and review the situation in the light of expanding food technology.

Mr. Mulherin I have three comments to make.

On the subject of dried fruit: raisin quality work is being undertaken by a joint Committee of Experts of the International Sultana (Raisin) Agreement countries – Australia, Greece and Turkey. I would hope their findings will be taken into consideration in any international food standards work.

Secondly, in developing standards – especially trade standards – it is important to have as wide as possible a participation of exporting and importing countries. For bananas, for example, it is essential for Latin American countries to participate since they account for more than 80 per cent of banana exports. I refer this to both the ISO and Codex Committees.

Thirdly, the principle behind standards is to promote international trade. I express the hope that participants in work on standards keep this idea in the forefront. There are cases of standards being developed and used essentially for purposes of trade protection which is a contradiction of their apparent aim.

Mr. Goodall Virtually all Latin American countries take part in these Conferences, but one difficulty is expense, as these Conferences tend to be held in Europe or North America. One of the virtues of the Codex system is that it costs nothing for a country to be a member. Once a member, the country is then expected to set up a Codex contact and nominate an officer who then receives all documents. This very extensive documentation is of unestimable value. Even if a country cannot attend individual conferences, they can put in written comments pointing out their problems and views. One of the problems is that membership of the committees tends to come primarily from the developed countries, and the standards set by these committee tend to be high – perhaps unattainable in the developing countries.

M. Duellin The ISO standard set for bananas is very flexible, and is more for information and guidance than for regulation.

Mr. Goldenberg Little has been said today about fresh and dried fruit and vegetables, but more about processed fruit. One lesson we have learned which may be of interest is that standards must not be restricted to the final product. It is necessary to go back to the country of origin and include such things as cultural techniques, harvesting, storage, methods of transport, marketing, as well as the final product when it gets here. Otherwise a very false picture may be obtained.

Mr. Alles On the question of standards in relation to developing countries and development of industry in them, while appreciating the high standards required for the markets here, since in most of our countries industries are only beginning, there is a lack of capital investment and technical competence. I am not trying to make out a case for lowering standards but the problem is a very real one and certainly very vital to our countries.

Dr. Fidler What the last speaker, and what Mr. Goldenberg, said underlines the points brought out by Mr. Cave and Mr. Brown earlier in the Conference. An exporting country can benefit greatly by using the expertise of an existing commercial organization which will advise on selection of varieties, on cultivation, on packing, on transport and, finally, on educating the consumer at the receiving end about the virtues of the fruit being purchased.

Mr. Goldenberg Is the low temperature chilling injury to avocado commercially very important? What is the minimum temperature for three weeks storage which will not cause chilling injury after ripening?

Dr. Hatton In California, 45°F. is the temperature recommended; length of time, certainly no longer than three weeks. With Florida varieties we do not like to go below 50°.

Mr. Goldenberg I get the impression that 45°F. is too low.

Dr. Hatton The sooner the fruit softens in transit the sooner it will rot: higher temperatures encourage softening.

Dr. Yankey Firstly, I understand that West Indian avocado varieties all have poor keeping qualities; what are the crucial factors responsible for this?

Secondly, in the West Indies, particularly Dominica, all the avocado varieties are tall trees. Is this a varietal characteristic or a climatic and/or agronomic characteristic?

Dr. Hatton I am unable to answer the first question. Biochemical factors, connected to the genetic make-up, are involved. West Indian varieties can be kept for 14–15 days at 50°F: beyond that they suffer chilling.

Secondly, this is a varietal difference.

Dr. Mapson Is there any advantage of having high carbon dioxide as well as low oxygen? Has Dr. Hatton tried to separate the effect of these gases?

Dr. Hatton We have tried all combinations. We feel you cannot go below 1% oxygen or go too high on carbon dioxide. There must be an optional combination of the two. We are going to raise oxygen to 1.5%, but this is strictly by trial and error.

Prof. Tai In my experience in the West Indies there does not seem to be a standard relationship between oil content and palatability of avocados.

Dr. Hatton I agree. We have done taste evaluations on avocados and determined the oil content of what remains, and found no partiality one way or the other. As the season develops the oil content increases, and the fruit later in the season are better in flavour, but it is difficult to tell the difference.

Prof. Tai We do not even notice the early avocado being less palatable. The moisture content of the pulp has a relation to the oil, of course. When the fruit is big there is a high moisture content, and it is less acceptable than the one which has a low moisture content.

Dr. Hatton We have found that on any given tree the larger fruit has the highest oil content because it came from the earliest bloom.

Mr. McFarlane Is there any use for avocado oil?

Dr. Hatton California some time ago was trying to use avocado oil in the cosmetic field. It is an unsaturated oil, rather like olive oil. Today there is no commercial application that I know of but with high oil content varieties, as in Israel, something could be done.

Dr. Gazit There is some avocado soap and avocado cream being made in Israel, on a very small scale. There is not much surplus oil at present but in future it may be developed. There is future for it only in countries raising high oil content varieties.

M. Cadillat Avocado oil is produced to the extent of 40 metric tons/year, costing 20–22 francs/kg. in California. There is also some production of avocado oil in South Africa, but this is very small. World production must be about 50 tons.

Concluding Session

Friday 19th September
Afternoon

Chairman

Dr H.C. Pereira, FRS

Director, East Malling Research Station

Concluding session

Chairman - Dr H. C. Pereira, FRS

This afternoon we have the very difficult task of summing up and picking out the essential points to carry away with us from a week of very wide ranging lectures and discussion and, in order to do that, I have asked the Chairman of each session to concentrate on the points which really highlight our thinking in this meeting. I will call on Dr. Spensley to start.

Dr P. C. Spensley

The session on Monday morning was broadly introductory to the subject field of the Conference, and the many important points made are somewhat difficult to summarise briefly.

Professor Aylward spoke about the requirements for the establishment of a tropical fruit industry, and in this emphasised the complex of technical factors involved. Important amongst these were:—
to have the raw agricultural produce in the right quantities and of good quality at the right time; to have available suitable water supplies, packaging materials, etc.; to design buildings and to select equipment with flexibility of production in view; to provide good storage facilities for raw materials and finished goods, and to have satisfactory transport arrangements; to have the necessary trained personnel for management, technologist and technician functions and access to sources of expert advice and information. Provision of technical services for quality control of the raw materials and product, as well as for plant maintenance, were essential. The need for import substitution was often an important stimulus to the establishment of industries in producing countries but to get the scale of operations required for economical production commonly necessitated working to export markets also.

Mr. Candia spoke about the marketing of tropical and sub-tropical fruits in Britain. He indicated the leading role of the citrus group but pointed to its present state of over-production in the world. The worthy efforts of individual producers to guard against the effects of this by elimination of poor quality and undesirable varieties, and also by prolonging the season of production, would not, however, in the long term, avoid the marketing of excessive quantities.

The pattern of marketed citrus products was always changing, as witness the recent growth of the deep frozen concentrated pure orange juice. With regard to patterns of marketing and distribution, the move towards establishing Marketing Boards was important.

Most production of pineapples was based primarily on the processed product, and marketing arrangements were often similar to those for citrus. As with citrus,

the value of by-products from the processing operations was recognised.

The avocado was sited as an outstanding example of enterprise and co-operation where as a result of research and well-organised promotion, trade in the commodity had increased very rapidly. There was a lesson here which might be applied to a number of other tropical fruits.

The nature of the problems in production and transport of bananas were such that this commodity had been concentrated into the hands of a small number of large organisations able to provide major facilities in research, technical supervision, transport etc.

Regarding transport and packaging, the value of small packs to facilitate handling at the retail point of sale, and the advantages of palletisation were stressed. The likely importance of further developments concerning controlled atmospheres for transport and storage was also mentioned.

Mr. Cave, speaking on the trade in tropical preserved fruits, referred to the changes in the distribution pattern of retail food stuffs due to the rapid development of the multiple chain stores and supermarkets. As an example, lychees, which formerly were despatched almost exclusively to the catering trade, are now distributed in small packs and sold direct to the public in the bigger stores.

Regarding costs of production, the example was quoted of canned mango, where the South African product, though inferior in quality to the Indian, had about double the sale in the United Kingdom because it was produced and marketed more cheaply.

The commonest faults found in products offered to the UK market were:

a) inadequate grading
b) mixing good and poor quality fruits in the same can
c) over and under sterilisation
d) failure to use correct size of cans or properly lacquered cans
e) use of incorrect syrup strengths
f) packing fruits that have been allowed to lie for too long after picking
g) incorrect and faulty labelling and packing

It was suggested that as the marketing of preserved foods was now a highly complex business it was usually best for the manufacturer to have a sole distribution arrangement with a company on whom he could rely for correct advice on various matters such as can sizes, packaging and labelling.

Finally, it was emphasised that all selling requires publicity and that various media were available.

In the discussion period, advice to new entrants into the field of fruit processing was sought particularly regarding the products to go for. If products were chosen for which the volume that could be produced was small, production might not be viable, and it was important to plan for maximum use of processing facilities. This meant considering a range of products.

With regard to advice for people and organisations in developing countries on the markets for fruits and fruit products in the UK, the Marketing Division of the Tropical Products Institute exists to answer just such questions.

A representative of FAO emphasised that because of their cost, the build-up of markets for processed fruit within the developing countries themselves was inevitably slow. This had to be taken into account in establishing new processing enterprises.

Mr. J. Candia

Monday afternoon's session was an interesting and valuable mixture of statistical dissertation data, very accurate, on the consumer levels in various countries of a large range of commodities, followed by a very adequate dissertation on marketing, of both existing products and possible future products from tropical countries, in Germany. These speakers were followed by three international experts on transport who gave extremely valid papers on modern methods of transportation not only with regard to refrigeration and conditioned air storage but also the use of containers. In all this, the message from the afternoon session came through loud and clear. First of all, on account of cost, only ship good and consistent quality. Having achieved the good and consistent quality, size it, grade it, and pack it properly, so that it will have eye appeal as well. Thirdly, ship it in ideal conditions. It is necessary to make certain that the fruit is shipped at the right temperature with the right humidity; make certain that the necessary means of transport are available, or do not attempt to do anything without those means of transport. Overall, what emerged was really that the consumer rules the destiny of the producer and the trader and will decide whether they live or die, regardless of what fruit is concerned, or where it comes from. No-one can afford to ignore any facility which can assist co-operation. However much talk there may be about out-turn per acre, needs of the future, varieties which are easy to pick, easy to handle – in the end it is the consumer who buys the fruit, not just to look at, but to eat. If consistent good quality is not maintained, there is no point even in starting. That was the message from the session.

Monsieur R. Deullin

The session on Tuesday morning indicated the diversity and complexity of the problems arising in the transport of tropical fruits and showed we must take care not to generalise and that the data published should only be applied to very specific cases. The paper on the storage and transportation of Florida citrus is particularly interesting because it gives much precise detail: we must remember that this data applied especially to the case of Florida.

I noted among other important points that we should not store de-greened fruits and that we must not apply the conditions specified to citrus fruits for other regions where higher storage temperatures may be required.

The discussion showed that there is little chance of lowering of air freight charges. Air freight seems reserved to high quality luxury fruits and these fruits must be produced and handled for air freighting from the point of growing and through all stages of packaging and transport.

The third paper, which concerned the biosynthesis of ethylene in bananas, shows that by limiting the synthesis of ethylene in the fruit it is possible to enhance the storage life. This opens the way to many avenues of research. It can be said that the prolongation of the storage of bananas will be obtained by any means which will make it possible to limit the synthesis of ethylene, including lowering oxygen concentration, as pointed out by Dr. Mapson, and by other means also. So, this is a paper which I consider very important.

As regards the work of Professor Beccari on banana transport, using vitamin treatments to supress the metabolism, this research makes an interesting contrast to other research work on modern sophisticated fungicidal treatments. Such work is being done in a number of countries with a view to controlling the fungal rots of bananas. It seems to me necessary that work should continue in this direction, and also on actions and products which delay the development of the climacteric phase of bananas.

There are great variations in the properties of bananas and this must be taken into consideration if research work is to be of maximum value. One often sees that research work published without precise details of the material used, of the method of growing, of the variety and the degree of ripeness being clearly stated.

Dr P. H. Lowings (on behalf of Dr E. C. Bate-Smith)

Tuesday afternoon was devoted very largely to physiology, a scientific subject; in the audience were people from many countries, some buyers, some sellers, some interested in transport, many interested in marketing: how many knew, in fact, what the basic background was and the reasons why this physiological work was being carried out? As I saw it, the reasons, particularly for the first half of the afternoon session, were mainly in relation to damage and loss following or before harvesting. Losses, as Dr. Bate-Smith said in opening the session, are staggering in many tropical countries. For those of us coming from the highly developed countries to see in the field perhaps 50% of the crop lost due to disease or to physiological causes is quite startling, particularly as it is accepted as an act of God or an act of nature. At lunchtime I was talking to someone from Malaysia, who spoke of difficulties of shipping out Malaysian fruits due to the difficulties of keeping them cooled, in damaging them when they are cooled and the distances of the markets and the distance it was necessary to ship the fruit and the expense of air freight.

The physiological work, at least the first part, was in relation to chilling damage. This is damage which occurs not when the material is frozen but when temperatures are reduced only perhaps to 5, 6 or 7°C. This is being investigated by Mr. Coursey and his colleagues with the intention of finding the physiological reason behind this. Having found it, can we alter it? Can we therefore begin to ship out our fruits and vegetables by sea or by other slower but cheaper means of transport than air, and expand the market from those countries? Losses come in many ways. The speaker on banana diseases summarized it well when he separated losses into three different parts. There can be losses occuring in the field, losses occuring in transport and those due to other causes. Many of us working in separate compartments do not realise what losses occur in other compartments. My own experience has been that you can get losses occurring during cultivation, losses during handling, losses in transport, losses at the docks, losses even right up to the housewife: if she does not know how to cook the material properly you still have a loss.

That was contrasted in the second half of the afternoon, when we had a very able dissertation on new methods of harvesting oranges. The thing that was brought home to us was the very wide difference in sophistication between countries producing tropical fruits. In America, problems were mainly those of keeping down costs of labour and so they were developing methods of spraying citrus trees to induce abscission or shaking the fruit off. That left me thinking it was a fine thing in America but if you tried to introduce that in some developing countries where there are serious problems of unemployment for labour you would be in trouble.

Prof. F. Aylward

On Wednesday morning we had a number of papers from different parts of the tropical world – Ceylon, India, Pakistan and Ghana, and also from Australia. The papers were all concerned with different aspects of food preservation and processing. Perhaps one of the most interesting things that emerged was the frankness of speakers describing the difficulties they have had in developing private or State food industries in the different countries.

Some of these problems were outlined in my introductory paper on Monday morning last and have been summarised earlier this afternoon. But I think that we are all interested in the statements of the special problems in the different case histories.

It became evident on Wednesday morning that what had been said earlier on the processer/grower relationship was very important, and that many developing countries had still a great distance to go before getting anywhere near the ideal. Various people spoke, for example, about the difficulty of getting adequate amounts of a variety of fruit suitable for processing. We had some interesting information about different new fruits that are not yet on the world market and only to a limited extent on local or regional markets. Dr. Charley told us something about the possibilities and difficulties of getting new products on the market.

Some speakers brought to the surface the difficulties – partly technical and partly economic – in securing auxiliary raw materials. One speaker mentioned the problems that have arisen in governmental as well as in private enterprises because of heavy import duties on essential auxiliary materials, such as sugar. This problem

of import duties occurs frequently with packaging materials. It is, perhaps, not easy for some of us here to realise the importance of the costs of packaging materials in a country where incomes are very low and where there may be strict currency control. Hence the need for an understanding in Government circles in any particular developing country of the inter-relationship between these economic and technical factors.

Reference was also made in two papers to the problems of carrying out the actual processing operations once a factory had been established. From this emerged a picture of the very great shortage of personnel in many countries for food preservation and processing operations, and the importance of training schemes.

We in Britain may not appreciate the effects of dichotomy in respect to the agricultural and processing advisory services. By tradition, much of the government-sponsored agricultural advisory work in Britain stops at the farm gate; it is assumed that, outside the farm gate, private enterprise takes over. This may be logical in this country but may be a grave disadvantage in another country that has imitated our administrative system; if agricultural advisory work stops at the farm gate, then there may be no agency to deal with the whole area of processing.

Some speakers brought up points relevant to the discussion at the opening session on the different sizes and shapes of industries at different stages of development. We had a picture of a private firm in Ghana beginning with very little capital and growing in spite of many difficulties. We had accounts in terms of small State enterprises in other countries and useful information on what one can describe as the evolution of the food industries. We had also some information about the changes in local consumer demand and of the initiation of enterprises based first on the concept of import substitution.

Dr L. W. Mapson, FRS

Wednesday afternoon was devoted, more or less to problems associated with the West Indies and in the first half of the session, concerned mainly the conditions which exist for the export of fresh fruit in the Windward Islands, and for the development of a processing industry in the less developed territory of Dominica. In the paper on the Windward Islands, the point which interested me most was that despite the fact that the expansion of the quantity of bananas exported had risen very markedly over the past few years, because of the introduction of modern refrigerated transport ships, nevertheless the quality of the fruit which was being packed into ships remained constant. Now, this was attributed by the speaker to increased incidence of fungal diseases, but it seems unlikely that diseases should have increased over those years. It seems to me that it probably means that with more extensive growing there has been a decline in the standards of handling fruit prior to its shipment.

The second speaker in the first session interested us by enumerating the conditions which must exist for the establishment of a processing industry. To recount these briefly: there must be incentive to growers, or else they will not grow fruit; secondly, there must be adequate transport and shipping facilities available and thirdly, most important of all, an assessment must be made of possible outside markets for which the fruit can be put for sale.

In essentials, raw materials must be available at prices at which growers will be able to sell, and which are economical for a growing industrial unit, and the point was emphasised that in any contemplation of the formation of such a unit, conditions must be such that it should remain functional for the best part of the year, otherwise it would be uneconomical. A plea was made that since private capital might not consider this feasible, in Dominica, subsidy by the Government would appear to be necessary.

The second part of the session dealt mainly with improvement of quality. The work of the Citrus Research Unit of the University of the West Indies was described and broadly its aim lies in three main sections. First of all, nutrition of the plant; secondly, the selection of improved varieties, and thirdly, control of pests and diseases. The interesting statement was made that an increased yield of citrus fruits had resulted from the simple addition of lime, the increase being in the region of 40%. The point was again emphasised that fungal diseases were being controlled by fungicides and insects by insecticides. The work of the research association was being deployed to disseminate information to 30,000 growers in the area. In the next paper we also had a description of the work going on to propagate better types of the lesser known tropical fruits and a description was given of the criteria of quality which are now being used for their adoption.

Finally, we had a paper on the development of a new citrus fruit, the chironja. This fruit, which seems extremely interesting, is a hybrid between the orange and the grapefruit and appear to have the advantages of both and the disadvantages of neither, and it is hoped to hear more about this in the very near future. I, for one, would like to see it and try it.

Prof E. A. Tai

On Thursday morning, attention was transferred from the general to the particular, and three groups of fruits were the subject of excellent papers. First there was a paper on the production of dates, then there was one on melons, after this there were three papers on mangoes. In all these papers different aspects of production were treated.

In each instance there was a short discourse on the botany of the fruit crop and cultivars were described; some of the descriptions were illustrated by colour slides. We were told the preferences and tolerances of these fruits as regards climate and soil. It appears that all three groups of fruits – the mangoes, the melons and the dates – are really best suited to a subtropical climate with a rather dry atmosphere during part of the year, but they all also possess in common the requirement of high soil moisture; lack of this in some instances, particularly melons in Cyprus, may limit production.

We were told of cultural practices, how the land is prepared and the spacing of plants in the field, how the

fertilising was done. In this particular connection, we were told of the fertilizing problems of mangoes in Israel under conditions of high pH of calcareous soils; here the use of iron chelate assists in creation of conditions suitable for the absorption of the nutrients. The iron chelate did not itself provide the metallic iron for the plant, but made possible the use of iron already present.

One very interesting part of these descriptions of cultural practices was the method of propagation of mango, the use of a tip-grafting technique which is not very widely known; this will have very good application in those areas in which mangoes are grown. We were told of the yields and the methods of harvesting and it transpired that there is difficulty in determining when water-melons are mature for harvest when they are grown on a commercial scale, and it could be inferred from what was said that the determination of the stage of maturity bordered on an art.

We were also given some information on the utilisation of the different fruits, the ways in which they are prepared and packaged for export, how they are stored and how they are processed. It was learnt that in addition to its use as a fruit the mango provides a base for many culinary and medicinal preparations.

Prof J. W. Purseglove

In the first paper on Thursday afternoon we heard of the pioneer work of Wardlaw and Leonard at the Low Temperature Research Station of the Imperial College of Tropical Agriculture in Trinidad in the early 1930's. This is one of the first places in the tropics where this type of work was carried out. Despite the fact that they have some very good avocado pears in Trinidad, as I know well from personal experience, it is still thought necessary to select from local and introduced cultivars to extend the cropping season and produce surplus fruit for export. It is also interesting that a technique of grafting very young avocado seedlings has now been worked out. This propagation from very young materials is now being used with many of our tropical tree crops.

The next paper dealt with the ethnobotany of Southeast Asian fruits and was of particular interest to me because it is one of the few papers which deal with this aspect of fruit culture. We were shown how the durian, the mangosteen, the rambutan and the langsat fit into the socio-ecological systems of the region. In each region of the tropics, in fact in most parts of the world, local people have their individual preferences for fruit flavours and consistencies; some like them sickly sweet, some like them rather sour, some like them pungent and some even like them malodorous. In urban areas within the tropics food habits are changing; apples and citrus are being imported and local fruits are sometimes neglected. I feel that among the more affluent it is sometimes regarded almost as a status symbol to use imported apples or imported cans of peas and beans instead of local foods. Changes in food habits, which usually begin in urban areas, may result in lowering the nutritional standards. I was delighted to learn that now we can chemically analyse the stench of the durian.

The last two papers were concerned with the physiology of citrus crops. One dealt with sunburn of citrus fruits in Egypt and has introduced the modern technique of tissue culture to help to elucidate this problem. It was pointed out that the temperature of a fruit, particularly on the south side of a tree and on the sunny side of the fruit, can be very much higher than ambient temperatures. We were shown that there is a difference between cultivars in regard to this condition, and that it is necessary to select and recommend cultivars best suited where sunburn occurs.

Finally, the nutritional aspects of citrus in the Lebanon were discussed, and I think the lesson we learned was the importance of carrying out experiments locally, not only in the particular country, but also in the local regions of the country, using local cultivars, if you want to get the correct fertilisers or treatments for the crops. There is a danger of applying results from another country without sufficient local experiments. It was also shown how the indiscriminate use of the fertilisers which may be locally available, is not always in the best interest.

The point which came out from this paper, and which has been shown in many others, is the importance of carrying out research locally in your own country under your own conditions with your own cultivars instead of merely applying knowledge and results from elsewhere, although the latter is often a useful guide in initiating work for a particular region.

Dr J. C. Fidler

The theme of this morning's session was standardisation.

First, we heard something of the work of two international agencies, one governmental – FAO, and the other non-governmental – ISO. I say 'something' because the organisation of both is highly complex.

The FAO work, on the Codex Alimentarius, is aimed at the protection of the consumer – protection of health, labelling, fair trading practices, analytical methods for pesticidal residues and additives. It is cast in a more legalistic mould than that of ISO, the objective being to harmonise international legislation.

ISO's work, on the other hand, is concerned with methods of sampling, analysis of natural components, and recommendations for storage and transport. The objective here is to attempt to harmonise the at-present somewhat conflicting national standards.

There is inevitably some overlap, but the outcome of both should be the removal of barriers to trade.

There may exist other, artificial, barriers, e.g. the regulations of certain continental railways concerning the types of package they are prepared to handle. This would be only one of the many aspects of the problem of establishing an export trade, which an established commercial marketing organisation could help to overcome.

The final paper and the subsequent discussion were concerned mainly with a topic, the importance of which

cannot be exaggerated. This is the choice of cultivars – in this case of avocados – suitable for commercial growing and marketing. This is, of course, the basis for establishment of trade.

Chairman – Dr H. C. Pereira, FRS

In this Conference, we have heard papers covering extremely wide ranging subject matter contributed by people with experience in research, in field practice and in commercial operations concerned with tropical fruit. For me the high-lights, of course, have been the scientific ones and I would like to draw the attention of the many non-scientist members of the audience to the unusual and exciting situation in which experiments of very high practical and theoretical interest were reported right up to date to within a month of the meeting.

The major part of the meeting, however, had been devoted not to research, but to practical problems of developing tropical fruit industries, particularly for export.

Having lived for many years in the tropics and having recently had an opportunity to study the fruit industry of the UK and the data for Europe, I should stress that Europe, including the British Isles, grows more fresh fruit than it can eat or process in most years, in spite of high quality and skilled marketing. Even when producing such a hardy and transportable fruit as the apple in orchards within fifty miles on good roads from Covent Garden market, growers have to invest large sums in elaborate cold storage either on the farm or in co-operatives and many of them have controlled atmosphere gas storage of sophisticated design. For the more conventional fruits there are highly developed, long established trade channels along which fruit flows to supply the out-of-season markets. Against this background the consistent advice given to the Conference throughout the week by more than a dozen of the speakers, and ably summed up by Mr. Candia, is that new ventures in the production of tropical fruit for the UK and European markets should concentrate on the high standards of the luxury market, i.e. top quality consistently maintained, efficiently transported and skilfully marketed.

Most tropical fruit is eaten fresh and near where it is grown. It is very difficult, therefore, to persuade village growers of the completely different methods of handling and standards of selection which are needed for so exotic a trade. All of the examples and case histories given in the course of the week had pinpointed *management* as the key input. Without adequate management skills and energy, technical knowledge is of little help and research is not developed into practice. Part of the skill of management is to know where to get technical advice and how to recognise new troubles. Here the Tropical Products Institute has over many years been fulfilling a key role. In particular only such a centre of scientific experience can identify the problems which need new and original research as distinct from problems of the application of known techniques.

The outstanding success of the large commercial enterprises which undertake an integrated process of supervision of growing, packing, transport and marketing is based on their ability to organize and maintain a consistently high standard of management throughout. There is clearly every advantage in new tropical ventures seeking co-operation, advice and help and even possibly partnership with such organisations.

But first there must be a product to evaluate and there is a great deal of simple application of good horticultural practices needed to seek out and demonstrate the rich ability of tropical plants to produce luxury fruit. Dr. Bharath of Trinidad illustrated the type of essential preliminary work, the collection, comparison and selection of ecotypes of promising lines of fruit. He demonstrated also what highly practical results can be obtained. As another speaker told the Conference earlier in the week, it is quite pointless to attempt to interest major commercial enterprises in the product of six trees, no matter how exceptional these may be. It is clear that enough must be grown to select the best and to be able to offer initial consignments large enough for genuine market reconnaisance.

To conclude, I want to congratulate Dr. Spensley and his staff of the Tropical Products Institute for the extraordinarily wide and interesting combination of science and practice which they had succeeded in assembling for this meeting, which I personally have enjoyed greatly.

Dr P. C. Spensley

Before the formal proceedings of this Conference are closed – and we try on these occasions to conclude fairly early on in the final afternoon, so that there may be a continuation over tea of the equally important informal discussions – I do want to say some words of thanks to a number of people.

First, I would like to say that whilst it is for others to judge how successful this Conference has been, my fellow colleagues in TPI and I have ourselves derived a great deal of valuable knowledge and pleasure from it and from the opportunities provided for meeting you all. You will appreciate, I know, that the running of a Conference of this sort depends on the cooperation of a large number of people. Dr. Jones and Mr. Coursey of the Food Department and Fruit Section of TPI, Dr. Pickering and the members of staff of his Scientific Secretariat, and members of the TPI Administration have all worked very hard. But they have also had very considerable help from various people outside the Institute.

First amongst these, I would like to thank the outside members of the Conference Programme Committee for all their help to us in the planning stages of the programme for this meeting. I would also like to mention of the name of Mr. Chamberlain, our very helpful contact man in the Ministry of Overseas Development.

Next, I would like to express our very sincere thanks to the Commonwealth Foundation for making funds available to enable some of the overseas delegates to be

here with us. Then I wish to say how very grateful we are to the Dean of the School of Pharmacy, to his Assistant Secretary, Mr. Jones and the staff under him, and to the Canteen Manageress, Mrs. Jenkins and her people for all the efforts they have made to accommodate us and to provide for our needs. We also thank the Ministry of Public Buildings and Works for making this facility available and for providing certain special equipment.

We are all, I am sure, most grateful to the Minister of Overseas Development for opening our proceedings and for his reception there on Monday evening.

We have been very pleased to have the FAO join with us on this occasion and, as a result of this cooperation, we have had the very valuable loan of their interpreters. Our thanks go too to the interpretors themselves for the very excellent job they have done. I am always myself full of admiration for their remarkable skill.

Then I wish to say how indebted we are to the Chairmen of the various sessions, and especially to Dr. Pereira for the most difficult task of all, namely the chairing of this concluding session and for giving us his very stimulating and salutary summing up.

Finally, our thanks go to all who have presented papers at this meeting and to all who have joined in the discussion, so making this whole meeting complete.

When I was thinking yesterday about the people that I had to thank, I was looking out of the window and thinking that I certainly would not be thanking the weather man. Despite what those of you from abroad may have anticipated, and allowing for the fact that we English try to pretend that we do not have quite the rotten weather that we do, I think for September the week started pretty poorly, and I apologise to you for this. However, I see he is trying a little better today, and I hope this will last for those of you who are able to stay with us over the weekend.

To conclude, may I say again how glad we have been to have you all with us, and remind you that it is our endeavour in the Tropical Products Institute to help with the scientific, technological and marketing problems which we have been discussing during this week. We hope that we shall be seeing or hearing from you all in the near future.

Mr. L. A. C. Alles

It would be most inappropriate to conclude this session without some expression of thanks, especially from those of us who have come from overseas. We have of course benefited directly from the proceedings of the Conference. I must say that from our point of view in the developing countries, the programme has been tailor-made to our needs, but apart from this, as a by-product of the Conference, we have had the chance of meeting several people from the UK and other countries, who are engaged in similar work and this has been extremely valuable. You will have gathered from our contributions, particularly those from the developing countries, what our aspirations are with regard to the development of fruit industries, and from this point of view, we have gathered a great deal of information, which we hope to translate into practice when we return. This conference was convened by the Tropical Products Institute and to them we owe our gratitude for holding the Conference and making it a success; and to the Commonwealth Foundation which has generously helped some of us in the expenditure involving in coming here, I also convey my expression of thanks. Finally, I would like to say that fruit cultivation, fruit processing or trade, is only a means to an end, in the sense that finally it must all lead to the welfare of mankind, particularly the welfare of the less-developed countries. I am sure the proceedings of the Conference can be utilized to this end.

Mr. E. A. Odoi

I would like to associate myself with the words of the last speaker, and also express the hope that the ideas which conceived this most interesting and successful Conference will not die with its end. The production, transportation, storage, packing, marketing and diseases of tropical fruits and vegetables all are part of a subject which is extremely vital for developing countries. For that reason, I would like to see this Conference turn into a yearly or at least a two-yearly, affair, if that is at all possible: although, in making this proposal, I am not unaware of the hard work, the elaborate preparations and the cost which is involved. We could then say that this Conference is not ended, but that it has only been adjourned to meet again.

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